Quintessentials

口腔临床要点快速掌握系列

5

·中英文对照·

实用根管治疗学

Rational Root Canal Treatment in Practice

▶ John M Whitworth [编 著]

▶ 吕红兵 闫福华 [主 译]

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“口腔临床要点快速掌握系列”丛书（Quintessentials系列）是人民军医出版社国际口腔医学出版中心从国际知名的口腔专业出版集团——国际精萃出版集团(International Quintessence Publishing Group)新进引进的一套旨在提高口腔临床医生、学生综合能力的丛书。丛书内容涵盖口腔医学的各个专业。

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实用根管治疗学

Rational Root Canal Treatment in Practice

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内容提要

"口腔临床要点快速掌握系列"，是由国际著名的Quintessence出版集团近期出版的一套介绍口腔各科基本技术和最新理论的口腔专业丛书。丛书从2002年起陆续出版发行，我社第一时间引进翻译出版，以便国内读者同步了解国际口腔技术发展的新情况。本书由国际知名口腔专家编著，摆脱了一般专著照本宣科式编写模式，一切从临床实践出发，通过大量实例，讲解了根管治疗的最新理论和最基本、最重要、最实用的操作技术。本书采用中英文对照的编排方式，对提高读者的专业英语水平大有裨益，本书适合临床口腔医师和口腔医学生的阅读。

责任编辑 **杨 淮 林 菲**

序

牙髓病学是一门发展迅速的临床学科，新器械、新材料和新技术的不断出现推动了该学科的持续发展。对口腔专家而言，及时了解众多的新方法，并将其很好地应用于临床尚有很大困难，这就更不用说工作繁忙的普通口腔医师了。精萃集团出版的《实用根管治疗学》就是为解决牙髓病治疗过程中的这些困难而编写的。本书从解剖学的角度详细地介绍了从根管治疗到提高远期疗效这个过程中牙髓病学治疗的难点。《实用根管治疗学》是精萃集团出版的针对普通口腔医师系列丛书中一本很有价值的分册，有助于口腔医师和学生更新知识。

主　编　**Nairn H F Wilson**

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第 1 章 牙髓病学基础

Fundamentals of Endodontic Disease

目 的

描述牙髓病和根尖周病的临床生物学基础，为合理的牙髓治疗奠定基础。

Aim

To describe the fundamental clinical biology of pulp and periapical disease, and lay the foundations for rationally based endodontic treatment.

要 点

通过学习本章，应该对细菌感染在牙髓病及根尖周疾病中的作用有清晰的认识，并以此指导临床根管治疗的每一步操作。

Outcome

After studying this chapter, the reader should have clear understanding of the role of microbial infection in pulp and periapical disease, and the need for this knowledge to translate into action at each stage of clinical root canal treatment.

牙髓病学简介

牙髓病学是临床口腔医学的分支学科，涉及到牙髓病及其并发症的预防、诊断和治疗。其内容广泛，包括以下治疗措施：

- 保存全部或部分健康的牙髓（盖髓术和牙髓切断术）。
- 保存和修复已发生不可复性牙

An Introduction to Endodontics

Endodontics is the branch of clinical dentistry concerned with the prevention, diagnosis and treatment of diseases of the dental pulp and their sequela. The discipline therefore has a broad scope, encompassing procedures which aim to:

- preserve all or part of the pulp in health (pulp capping and pulpotomy)
- preserve and restore teeth with irre-

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髓炎和牙髓坏死的牙齿(牙髓摘除术和根管治疗术)。

- 保存和修复根管治疗失败或在治疗中受损的牙齿(牙髓再治疗术和根管外科手术)。

在实践中,"牙髓治疗"通常就是指"牙髓摘除术和根管治疗术",这是一项准确性高、技术性强且发展迅速的临床操作技术,主要强调根管充填的形态和长度,以及满意的X线片充填效果。本书主要讲述成人的根管治疗,并为临床上安全选用各种适合的治疗方法提供理论框架。

versibly inflamed and necrotic pulps (pulpectomy and root canal treatment)

- preserve and restore teeth with lesions which have failed to respond to root canal treatment, or which were damaged in the course of such treatment (endodontic retreatment and surgery).

In reality, "endodontic treatment" is usually synonymous with "pulpectomy and root canal treatment", an exacting, technical and rapidly developing element of everyday practice, with its emphasis on line, length, and the attainment of a radiographically pleasing root filling. This book will focus almost exclusively on adult root canal treatment and provide a rational framework for the appraisal and safe application of established and emerging clinical methods.

根管治疗的技术关键

牙髓病学技术发展日新月异 。为了使临床治疗更加简便、快捷,预后更加良好,或为了获得更佳的美学效果,新的治疗系统、设备和材料不断涌现。多年来人们不断地将巨大的人力物力投入于这方面的研究,并取得了丰硕的成果。同样,我们也都经历过满心期待但很快化为泡影的沮丧(图1-1):每次失败后,所研发的昂贵的系统被束之高阁,同时我们转而采用原有的老方法,或者继续进行新的尝试。

The Technological Focus of Root Canal Treatment

Endodontics has never been shy of technology. New systems, devices and materials appear frequently, promising simpler, quicker, more consistent or aesthetically satisfying results. Many of us have invested heavily and repeatedly over the years, convinced and excited by the benefits to follow. Many of us have also known the brief honeymoon of interest and satisfaction which quickly evaporated into disappointment (Fig 1-1); another expen-



图 1-1　精心治疗后的又一次失败

Fig 1-1　Excitement and conviction evaporate into disappointment once again

sive system relegated to the back of a dark cupboard in preference for an old trusty method, or to be superseded by the next bright hope.

事实上，根管治疗的操作技术要求很高，因此医师们希望找到一种更加简单、可靠、有效的方法取而代之。加上目前要求保存牙齿的患者不断增多，使得全球的口腔市场对牙髓治疗产品，如新材料、新设备的需求空前高涨。但冷静分析后，可以发现这些所谓的新材料、新系统过于注重技术本身及治疗后时尚的“外观”，而不是认真研究疾病的机制，以期找到治疗的最佳方法，因而这并不能算是真正意义上的新方法，而只是出于商业目的。

The truth is that most of us find root canal treatment technically challenging, and wish there were simpler, more predictable and more efficient ways to do it. This, combined with a growing demand for tooth preservation, has seen unprecedented growth in world markets for endodontic product, and an insatiable hunger for new and attractively packaged materials and devices. To the dispassionate observer, this may seem to be pure commercial opportunism as we focus on technology and attaining the currently fashionable postoperative “look” rather than returning to the disease process and how it can best be managed.

作为一本实用的根管治疗手册的

At the start of a practical handbook on

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开篇，了解牙髓病和根尖周病的生物学基础对于预防和治疗是非常重要的。只有这样才能使治疗的每一步合理化，同时比较出新旧技术的优劣，最终为获得最好的治疗效果选择适当的方法。

root canal treatment, it is important to ground ourselves in the fundamental biology of the pulp and periapical lesions we wish to prevent and heal. Only then can we rationalise the mechanical stages of treatment and reveal where new and older techniques can optimise operator efficiency and successful outcomes for patients.

奠定基础：牙髓病学的生物学基础

根管治疗是防治根尖周炎的方法之一（图 1-2a）。在西方社会，30 岁以上人群中根尖周炎的发病率为 40%，60 岁以上可达到 62%。

根尖周炎之所以重要，这是因为：

- 它可引起局部疼痛和不适。
- 急性炎症扩散可引起严重的并发症，甚至危及生命（如颌面部蜂窝织炎、脑脓肿）。

Laying Foundations: The Basic Biology of Endodontic Disease

Root canal treatment is concerned with preventing and healing apical periodontitis (Fig l-2a), a disease which affects 40% of over 30s and 62% of over 60s in western society.

Apical periodontitis is important because:

- It causes local pain and morbidity.
- Acute exacerbation can result in serious, potentially life-threatening extension (e.g. facial cellulitis, brain abscess).



图 1-2　a. 根尖周炎是西方社会中一种重要而常见的疾病；b. 病原因素控制后，根尖周炎症可以治愈

Fig l-2　(a)Apical periodontitis, an important and common disease in western society. (b)Control of aetiological factors allows apical periodontitis to heal

- 与牙齿有关的慢性感染和炎症可能导致的全身并发症，这种观点正受到越来越多的关注。

由牙髓病变扩散引起的根尖周炎（图 1-5），可通过以下途径预防：

- 保持牙髓的健康。
- 在炎症累及根尖周组织之前治疗牙髓疾病（图 1-3）。

由髓腔内感染物引起的根尖周炎，彻底清除感染物并防止再感染，即可治愈根尖周炎（图 1-2a、b）。

牙髓损伤和牙髓坏死的病因学

牙本质和牙髓关系密切，所谓的“牙本质－牙髓复合体”被牙釉质和坚

- There are growing concerns about the possible systemic consequences of chronic infection and inflammatory lesions associated with teeth.

Apical periodontitis develops by extension of disease in the dental pulp (Fig 1-5). It can be prevented by:

- maintaining pulp health
- managing pulp disease before changes can progress to involve the periapical tissues (Fig 1-3).

Established apical periodontitis is caused by infected material in the pulp canal space and is known to heal predictably if the causative agents can be eliminated and prevented from returning (Fig 1-2a,b).

The Aetiology of Pulp Injury and Death

Dentine and pulp are intimately related. In pristine health, the so-called “dentine-



图1-3 早期行根管治疗死髓牙可以减轻疼痛并防止根尖周炎症的扩散

Fig 1-3 Early root canal treatment of a tooth with a dying pulp relieves pain and prevents apical periodontitis from developing

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硬的牙骨质完全密封起来。如果龋病、医源性医素或创伤（图1-4）将这层保护层破坏，多孔、管状的牙本质就会暴露于口腔环境，使牙髓易于受到化学、物理因素和细菌的损害。目前研究发现来自细菌的威胁是最严重的。

pulp complex” lies protected by an impervious layer of enamel and a sound investing periodontium. Breakdown of this protection by caries, operative dentistry or trauma (Fig 1-4) exposes porous, tubular dentine to the oral environment and leaves the pulp vulnerable to chemical, physical and microbial injury. The threat posed by microorganisms is by far the most serious.

口腔菌群和牙髓

20世纪60年代，研究者通过观察不同培养环境下（普通环境和无菌环境）暴露动物牙髓的实验证实了口腔菌群的毒力作用。随后用无菌动物进行的修复材料牙髓刺激性实验，以及通过牙齿表面封闭使牙髓处于无菌环境的实验，均得到相同的结果。目前有大量的证据支持以下观点：

- 如果处于无菌状态，牙髓具有很强的抵御机械性和化学性刺激

The Oral Flora and the Pulp

The virulence of the oral flora was demonstrated in the 1960s, when researchers investigated the effects of pulp exposure in normal and microbe-free animals. Similar observations have been made in subsequent studies on the pulpal irritancy of restorative materials in microbe-free animals and in surface-sealing studies where microbes where kept out of teeth. The overwhelming body of evidence currently supports the view that:

- If microorganisms are kept out of the pulp, it has remarkable capacity to

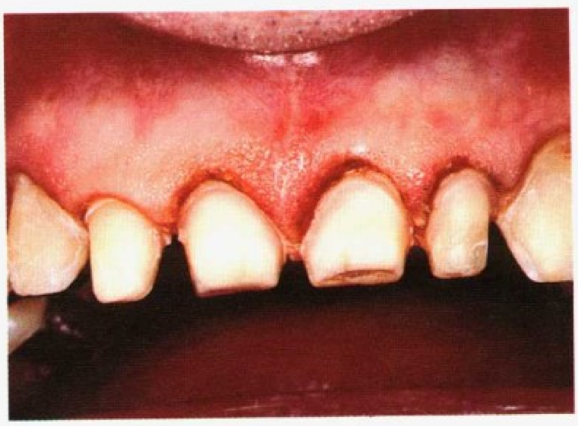


图1-4 直接暴露或通过牙本质小管间接暴露的牙髓，易受到化学、物理因素的刺激，特别是细菌的损害

Fig 1-4 Frank exposure of the pulp, or via porous dentine leaves it vulnerable to chemical, physical and above all, micro-bial injury

的能力。

- 修复体边缘的液体渗透和微生物对牙髓健康的损伤程度比酸和单体更严重。

- 口腔菌群及其毒素是导致牙髓发生重度炎症反应和牙髓坏死的原因。

牙外伤可使牙髓因根尖血供中断，发生无菌性、缺血性坏死而丧失活力，但大部分牙髓的坏死仍是在龋坏、充填龋坏的不断重复过程中由于细菌侵入造成的。约有 20%活髓冠修复的牙齿在20年中会出现牙髓活力丧失及根尖周炎，因此，在为 60 岁以下患者制定治疗计划时需要考虑到这些问题。

防止牙髓感染是预防牙髓坏死和根尖周炎的关键，这应当是所有牙科医师的基本治疗目标。不论我们的根管充填多么精确，最佳的根管充填物仍是健康的牙髓。因此，本书重点强调操作中对牙髓健康的保护，本系列丛书中另有一册讲述牙齿创伤的处理。

坏死的牙髓组织：根尖周炎的病因？

当牙髓受到激惹，感染的牙髓由

withstand and wall itself off from mechanical and chemical irritation.

- Acids and monomers are less of an issue for pulp health than the percolation of fluids and microorganisms at restoration margins.
- It is the oral flora and their toxins which seriously inflame and kill pulps.

Although a significant number of pulps lose vitality during traumatic events which sever their apical blood supply (sterile, avascular necrosis), most pulp death is still caused by microbial entry following repeated cycles of caries and dental intervention. Almost 20% of crowned teeth, for example, will have non-vital pulps and apical periodontitis within twenty years. This is a sobering reflection as we plan dental care for patients under the age of 60.

Avoiding pulp infection is key to preventing pulp death and apical periodontitis, and must be a fundamental goal of all dentists. However refined we become in root-filling teeth, the best root filling will always be a healthy pulp. A whole volume in this series is devoted to the preservation of pulp health in practice, and another to the management of traumatic injuries.

Dead Pulp Tissue: The Cause of Apical Periodontitis?

As pulp breakdown proceeds from the

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外周向中央而后向根尖方向发生崩解时，根管内容物开始刺激周围组织，产生炎症（图1-5）。作为经典诊断指标的X线检查所见的骨质吸收就是其后果之一。

过去，教科书将牙髓崩解产物和根管根尖部位的组织液滞留视为根尖

irritated and infected periphery to the centre, and then apically, canal contents begin to stimulate inflammation in the surrounding tissues (Fig 1-5). Radiographic evidence of bony resorption, the classic diagnostic sign, is one of the consequences.

Historically, textbooks have described stagnation and breakdown of pulp and tis-

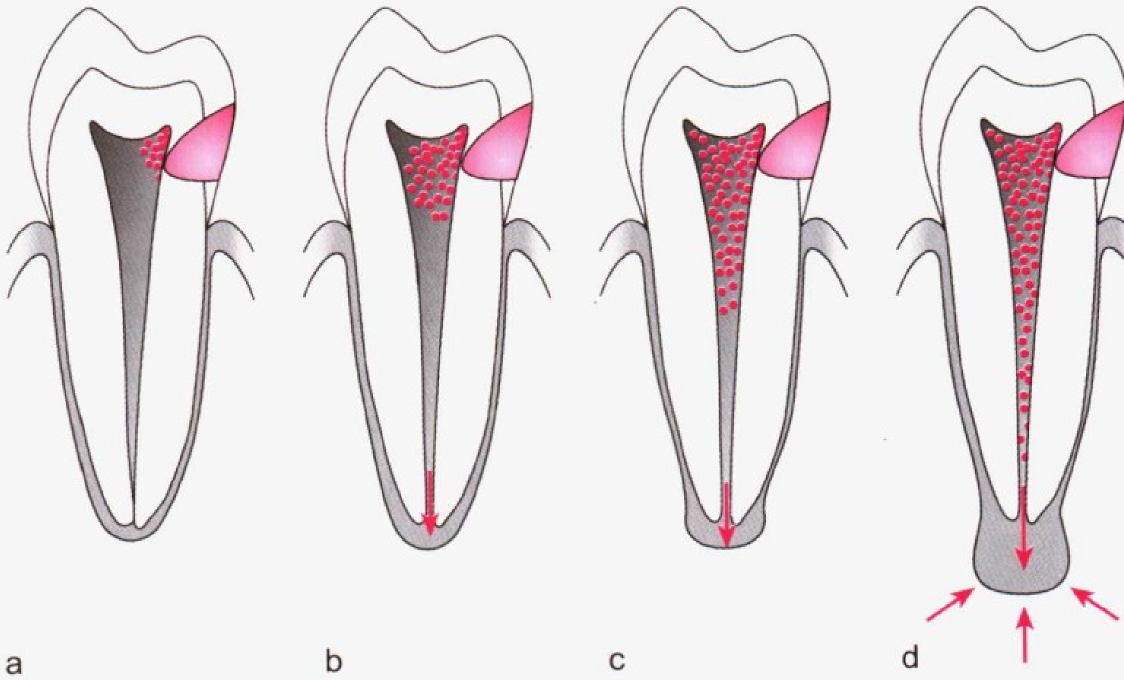


图1-5 牙髓坏死的渐进过程。a. 龋坏使牙髓暴露后，细菌侵入牙髓，牙髓产生局部炎症反应以消除或局限感染；b,c. 如未经治疗，炎症向牙髓中心及根尖方向扩散直至牙髓全部坏死，发生早期的根尖炎症；d. 根尖周炎形成；试图阻止炎症的继续扩散，患者出现的症状体现出感染与宿主抵抗力之间的平衡关系。如早期发现牙髓发生进行性坏死，可行牙髓切断术

Fig 1-5 The gradual process of pulp death. (a) Invasion of the pulp by microorganisms following carious pulp exposure. The pulp mounts a local inflammatory response in an attempt to eliminate or contain the infection. (b,c) Without treatment, inflammation progresses centrally and apically until the whole pulp is dead. Apical inflammation commences early. (d) Established apical periodontitis; an attempt to contain the advance of irritants. Symptoms experienced represent a balance between the contained infection and host defences. The progressive death of the pulp allows successful pulpotomy if caught early

周炎的主要病因，但这种宿主物质是否足以激发和维持根尖感染呢？

sue fluids in the apical part of the canal as major causes of this inflammation. But is this host material sufficiently irritant to provoke and sustain periapical inflammation?

20 世纪 70 年代的人体研究表明，在外伤使牙齿失去活力的病例中，只有那些根管感染的病例才发生根尖周炎，而牙髓无菌性坏死的牙齿并未出现这种变化。20世纪80年代对灵长类动物的研究表明无菌状态下使牙髓失活不会导致根尖周炎，但如果加入有菌的涎液，根尖周炎很快就会发生。我们很多人都曾经遇到过以下情况：牙齿创伤后保持几个月或几年都无症状，突然在没有明显诱因的情况下出现疼痛并发展成为根尖周炎。其原因就是创伤后最初发生的是牙髓渐进性无菌性死亡，几年后由于细菌（有时甚至只有一个）侵入到营养丰富、温度适宜的培养基中，外来细菌为根尖周炎症的产生和维持提供了必需的外源性抗原刺激，从而引起临床可见的病变。

Human studies in the 1970s showed that in teeth devitalised by trauma, only those with infected root canals developed apical periodontitis. Teeth with sterile, necrotic pulps showed no such changes. Primate studies in the 1980s also showed that aseptically devitalising a pulp does not cause apical periodontitis, but if infected saliva is added, apical periodontitis develops rapidly and predictably. Many of us have witnessed such events. Traumatised teeth can remain quiet and symptom free for many months or even years, then suddenly, without serious challenge, they become painful and develop apical periodontitis.The explanation is that the pulp died quietly and aseptically after the trauma. Many years later, the entry of microorganisms (perhaps even just one) to the rich, warm culture medium lying dormant within provided the necessary foreign antigenic challenge to establish and sustain periapical inflammation and the development of a clinically detectable lesion.

这表明：

- 仅仅坏死的宿主组织或阻滞的体液不足以引起和维持根尖周炎症，必须要有外源性抗原物质的存在。这里的外源性抗原是指

What does this mean?

- Periapical inflammatory lesions cannot be initiated or sustained by the presence of dead host tissues or stagnant body fluids alone. Foreign anti-

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细菌感染。

- 临床所见的根尖周炎是根管感染的结果。
- 只有清除感染和防止复发才能治愈根尖周炎。

根管感染的特点

尽管口腔内的常驻菌超过200种，感染根管的环境压力通常只允许4～6种细菌在同一时间内克隆繁殖。根管内的大部分细菌为专性厌氧菌，兼性厌氧菌、嗜CO_2菌也很常见。

特异性感染或非特异性感染

目前尚不了解是否任意细菌群落发展到一定大小（也许很小）都可以引起根尖周炎，还是必须有某种或某几种特定的细菌才能导致其发生。研究发现多种细菌都可引起根尖周炎症，如在根管治疗失败和未经治疗的病例中检出的菌群就大不相同，但还从来没有发现健康根管中有常驻菌群。到目前为止，还不能判断菌群中哪些是引起炎症的“真正罪魁祸首”，哪些是“无辜的旁观者”，另外，还没有针对致病菌的特异性药物。因此我们姑且认

genic material must be present, and that means microbial infection.

- When we witness apical periodontitis clinically, we are observing the consequences of pulp canal infection.
- Apical periodontitis can only be expected to heal if the causative infection is eliminated and prevented from returning.

The Nature of Root Canal Infection

Whilst the mouth is inhabited by more than 200 microbial species, environmental pressures in the infected root canal typically limit colonisation at any one time to some 4-6 species. Most are strictly anaerobic, though facultative and CO_2-loving (capnophilic) isolates are common.

Specific or Non-specific Infection?

What we do not know is whether apical periodontitis is a response to a critical mass (perhaps very tiny) of any microorganism, or if there must be certain organisms or combinations present for a lesion to develop. Research suggests that a wide range of bacteria can produce periapical inflammation. The apical periodontitis-inducing flora in cases of failed root canal treatment, for example, differs greatly from that of previously untreated cases, and the existence of a "healthy" root canal flora has

为所有感染根管内的细菌都是有害的，都具有潜在致病性。庆幸的是，我们采用传统的消毒灭菌方法可以杀灭大多数细菌。

never been established. For the present, we cannot distinguish the true pathogens from the innocent bystanders, and have no specific drugs to target them. Any root canal infection must therefore be considered unwanted and potentially disease-inducing. Thankfully, our standard methods of disinfection are able to kill most of them.

罕见的难治性感染

图 1-6 所示的两名患者年龄上相差几十岁，临床病史也大不相同。研究发现两人所患的都是一种常见的细菌感染性疾病，但机体自身对此却无能为力。因为他们的感染局限于坏死的牙髓，宿主防御反应和任何一种全身应用的抗生素均无法到达此处。

An Unusual, Inaccessible Infection

The two patients shown in Fig 1-6 are separated by several decades, and present very different chnical histories. We have established that they share a common microbial disease, but neither is able to do anything about it. Their infection is contained in the avascular environment of the necrotic pulp space, inaccessible to host

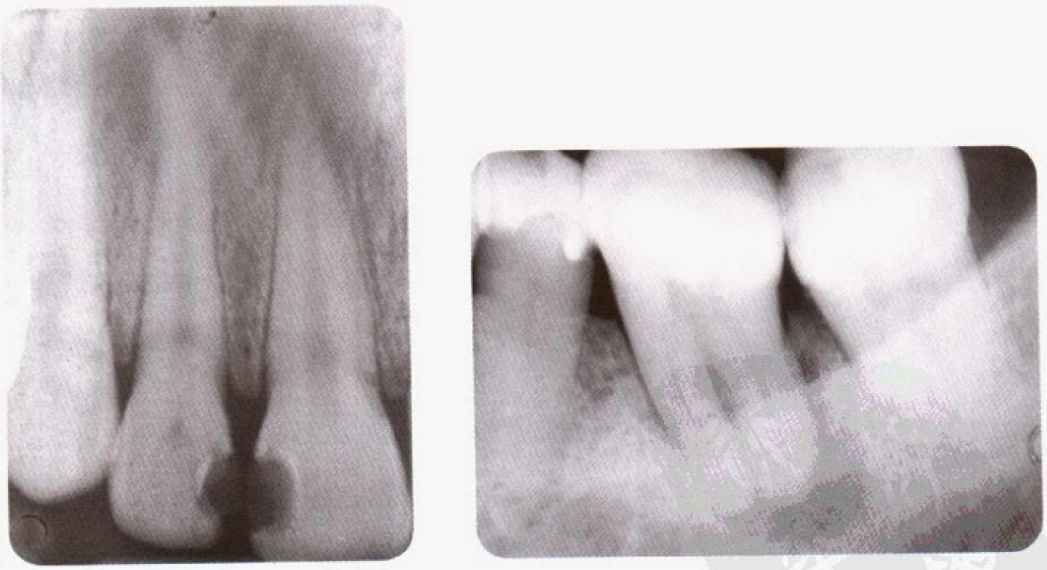


图 1-6　两名年龄相差几十岁的患者，都患有一种常见的细菌感染性疾病，但机体自身却无法清除感染

Fig 1-6　Two patients, separated by several decades, share a microbial disease which they are unable to rid themselves of

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治疗这两名患者，只有采取以下方法：

- 拔除患牙，同时去除了牙齿内的感染物。
- 彻底清洁根管系统，在生物学角度达到和拔牙术后一样的清洁。

根管系统经过正确清洁和严密充填后可以防止再感染，其中90%以上的根尖周组织都会完全愈合。

通过根管充填的好坏来评价医师的治疗结果，即X线片中根管中出现令人满意的白色线条，这意味着治疗过程的正确无误（图1-7），但仍需要对患者进行长期随访。

defences, and inaccessible to penetration by any systemic antimicrobial drug.

The only way these patients can be predictably healed of their disease is to:

- extract the affected teeth, including their infected contents, or
- clean their root canal systems as thoroughly, in biological terms, as an extraction would.

Complete periapical healing is a predictable reality in more than 90% of optimally treated cases in which the canal system is properly cleaned and densely sealed against re-infection.

Judging our outcomes is often based on the technical appearance of root fillings (Fig 1-7) – a pleasing white line implying that everything was done correctly. But we should also have an interest to follow up our patients in the longer term for the biological verdict on what we are doing and whether our methods allow our patients to heal.

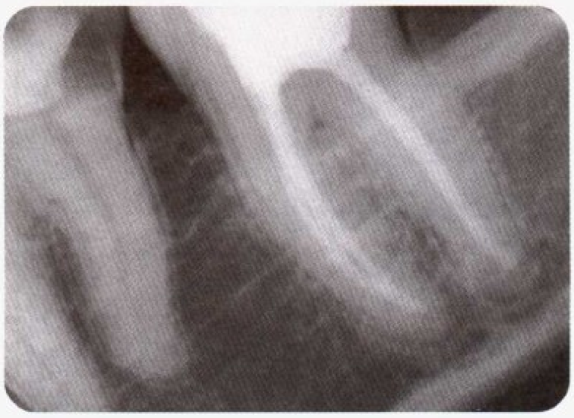


图1-7 一例满意的根管治疗，但控制感染的措施是否得当，只有通过时间来检验
Fig 1-7 An apparently successful root canal treatment. But were infection control measures adequate? Only time will provide the biological verdict

所有这些都意味着感染控制的观念必须用于指导临床根管治疗的每一步操作和每一次决定，包括冠方修复体的评价，龋坏控制，到治疗时患牙的隔离，找到所有的解剖结构，正确的清洁和塑形根管，直到最后进行严密封闭根管以防止再次感染。这些临床操作步骤还将在以后的章节中详细讲述，其中重点讲述感染的控制方法。

All of this means that control of infection must underpin all actions and decisions at every clinical stage of root canal treatment from initial evaluation of coronal restorations and caries control, through isolation, finding all of the anatomy, properly cleaning and shaping it, to sealing against new infection. Subsequent chapters will address these technical, clinical stages with due emphasis on rational measures for optimising infection control.

关于“难治性”病损

临床医师多年来致力于区分单独采用根管治疗术可以治愈和不可治愈的根尖周病变。通常认为，任何边缘有骨皮质化且直径≥1cm（图1-8）的根尖周病损都属于囊肿，需要做外科切除术。这是囊肿的临床特征，但其中很多囊肿都属于根尖袋形囊肿（图1-9）。如同慢性根尖肉芽肿一样，根尖袋形囊肿只需行简单的根管治疗术就可治愈。由于目前尚无法区分根尖袋形囊肿和真正的“难治性”囊肿，所以应在根管治疗的效果明确之后，再考虑是否需要外科手术治疗。

What About the “Therapy-resistant” Lesion?

Clinicians have tried for many years to distinguish periapical lesions which will respond to simple root canal treatment from those which will not. Classically, any lesion with a corticated margin and a diameter of 1cm or more (Fig 1-8) was regarded as a cyst, in need of surgical enucleation. These clinical features may well suggest a cyst, but very many of these lesions are apical pocket cysts (Fig 1-9), which will respond as well to simple root canal treatment as granulomatous chronic inflammatory lesions. Since there is currently no way of differentiating clinically between the apical pocket cyst and the “therapy-resistant” apical true cyst, there is rarely justification for surgical intervention before the outcome of high-quality, routine treatment is known.

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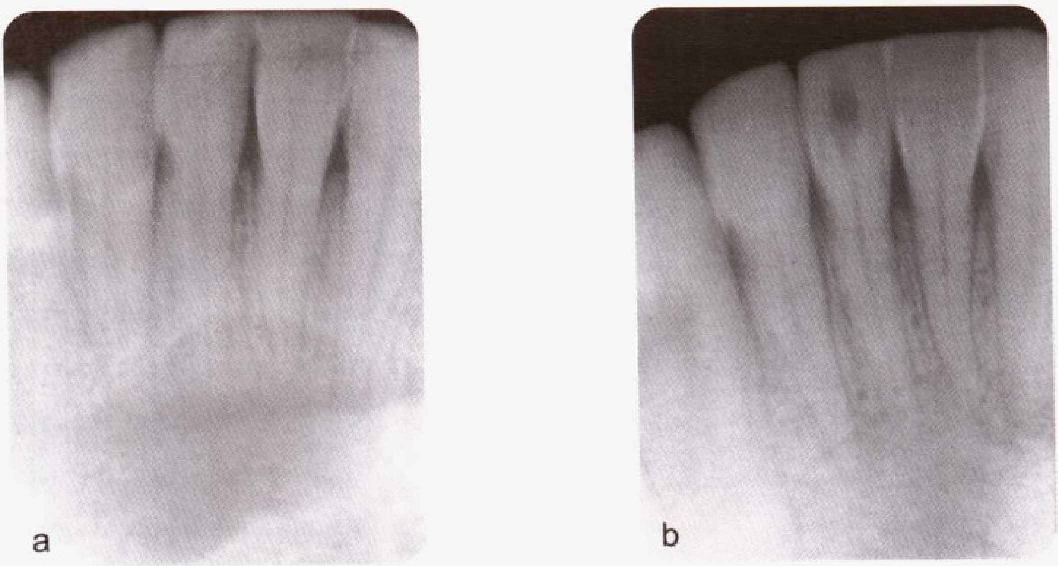


图 1-8 a. 难治性根尖周病损，一定需要外科手术治疗吗； b. 去除根管感染及冠方封闭后仅 6 个月，根尖就基本愈合

Fig 1-8 (a)A therapy-resistant lesion in need of surgical enucleation? (b)Substantial healing just six months after disinfecting the root canal and sealing the coronal entrance

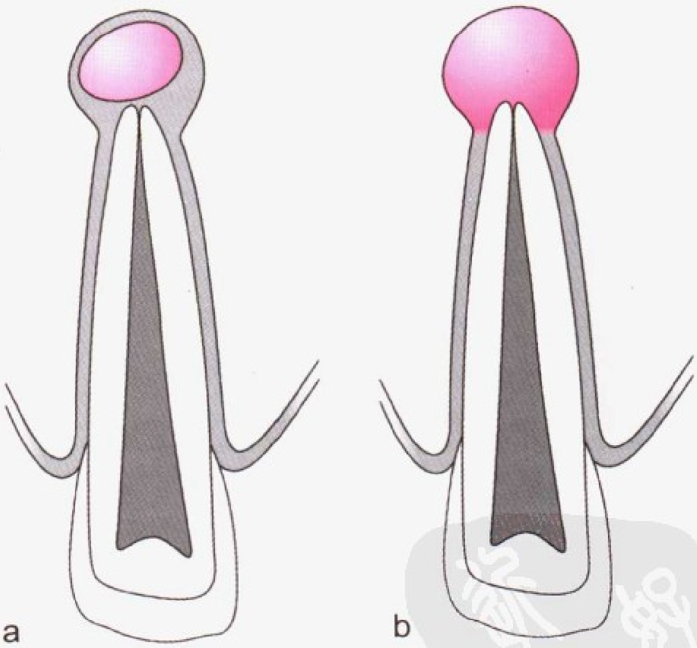


图 1–9 根尖真性（a）和袋形（b）囊肿。经过简单治疗，与根管系统相通的袋形囊肿很可能治愈。目前的诊断方法尚不能区分这两种囊肿

Fig 1-9 Periapical (a) true and (b) pocket cysts. The pocket cyst with its communication to the canal system will probably heal after simple treatment. Differentiation is impossible with current diagnostic methods

从感染控制的角度，可将大多数治疗失败以及"难治性"病变解释为：

- 没能进入到细菌定居的所有解剖部位（根管遗漏）。
- 没有运用正确的方法进行清理和消毒（隔离、扩锉、冲洗不充分）。
- 没有有效阻止残存细菌的再感染（根管充填不完善）。
- 没有有效防止来自口腔的再次感染（冠方封闭不严密）。

也偶见于下列情况：

- 对消毒剂耐药的菌群，如放线菌属或粪肠球菌。
- 牙根的外表面已经感染，难以通过根管预备或药物去除。
- 根尖处异物阻塞，通常是豆类蔬菜残渣阻塞引流口。

当然偶尔也有恶性病变漏诊以及根管治疗无效的病例。作为一名口腔专科医师，而非单纯的根管治疗师，应对不常见的病变提高警惕，但不管怎样，常见病例占多数，应尽可能采用简单的、可预后良好的、微创的方法进行治疗。

Most other failing cases and "therapy-resistant" lesions are easy to explain on infection-control grounds:

- failure to enter all of the anatomy harbouring microorganisms (missed canals)
- failure to use proper methods of cleaning and disinfection (inadequate isolation, enlargement, irrigation)
- failure to prevent reactivation of residual microorganisms (inadequate root filling)
- failure to prevent new infection from the mouth (inadequate coronal seal).

Rare exceptions include the presence of:

- a disinfectant-resistant flora, such as *Actinomyces spp or Enterococcus faecalis*
- an established infection on the external root surface, which cannot be reached by intracanal instruments and disinfectants
- apical impaction of other foreign materials, classically leguminous vegetable matter in teeth left on open drainage for extended periods.

There will, of course, be occasional sinister lesions which may be missed and which fail to respond to root canal treatment. We are healthcare professionals, not root canal therapists, and need to be vigilant for the unusually presenting or behaving lesion at all times. Nevertheless, com-

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mon lesions are common and should be treated by simple, predictable and minimally invasive methods whenever possible.

结 论

- 牙髓病科医师往往过于重视根管预备的机械形态和充填后的完美形态。
- 作为牙科医师，我们关注的重点应该是采用最有效的方法防治根尖周病，而不仅仅是完成漂亮的根管充填。
- 牙髓病和根尖周病是由微生物感染引起的。
- 成功治疗牙髓病和根尖周病，要求操作中的每一步都应注意彻底地去除微生物并防止再感染这些细节。
- 牙科医师有责任追踪观察治疗的生物学愈合效果，并改进临床操作，而且要对偶尔出现的治疗无效或恶性病变保持警惕。

Conclusions

- Clinical endodontics can focus too much on the mechanistic and the post-operative appearance of root fillings.
- Our concern as dentists should be the most efficient and effective ways of preventing and healing apical periodontitis, not just making aesthetic root fillings.
- Pulp and periapical disease are caused by microbial infection.
- Successful management of pulp and periapical disease requires attention to detail in eliminating and preventing the recurrence of microbial infection at every stage of treatment.
- Dentists have a responsibility to audit their biological, healing outcomes and modify their practices accordingly, and to be alert for the occasional non-responding or sinister lesion.

拓展阅读

Further Reading

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第 2 章 牙髓病的症状及应急处理

Endodontic Symptomology and Immediate Management

目 的

描述牙髓炎和根尖周炎的临床表现、诊断方法及临床应急处理。

Aim

To describe the characteristics of symptomatic pulpitis and apical periodontitis, and approaches to their diagnosis and immediate clinical management.

要 点

通过学习本章，应对牙髓病的临床表现、诊断及应急处理方法有更清晰的认识。

Outcome

After studying this chapter, the reader should have a clearer understanding of endodontic symptomology, diagnosis and rational measures for effective immediate management.

牙髓病急症

口腔菌群引起的内源性感染威胁着每个人的健康，其引起的疾病小到牙髓炎，大到威胁生命的败血症。很多需做根管治疗的患者在初诊时首先表现为牙髓炎或根尖周炎的症状，因此需要做出明确的诊断和应急处理。这些病人往往没有预约，医师只能抽空处理，因此很容易因为医师工作繁忙而处理不当。即使患牙需要拔除，简单的处理也能中止疾病进程，减轻患者

Endodontic Emergencies

Endogenous infection from the oral flora presents a threat to everyone with teeth on a disease continuum from niggling pulp inflammation to potentially life-threatening sepsis. Many patients requiring root canal treatment first present with symptoms of pulp or periapical inflammation requiring diagnosis and immediate management. These patients are usually unscheduled, squeezed into an already busy list of

痛苦，为制定最终的治疗计划赢得时间。正确的应急处理还可为后续的牙髓治疗打下良好基础。

appointments, and easy to mismanage under pressure. Even if extraction becomes the definitive outcome, a simple endodontic procedure can often halt the progression of disease and buy pain-free time to reflect on the final plan of care. Well done, it will also provide a valuable foundation for subsequent endodontic treatment.

应急处理应遵循以下外科原则：

- 通过可诱发的临床表现来明确病因。
- 去除病因。
- 化脓性病灶需建立通畅引流。
- 阻止扩散。

Immediate management should be based on the surgical principles of:

- identifying the cause by reproducing symptoms
- removing the cause
- securing drainage of any purulent focus
- preventing extension.

在应急处理中不一定要使用抗生素或止痛药，药物的使用必须不影响诊断，不能用药物来替代外科治疗。

This may or may not involve the use of antimicrobial or analgesic drugs, which should not be seen as a way of avoiding proper diagnosis and surgical care.

牙髓和根尖周的感染不应被忽视，应早期进行妥善治疗。大多数生活富裕、有良好的牙齿保健意识、身体健康的人群可能会认为牙齿脓肿是喜剧卡通片中的情景，但事实上仍有相当数量的人饱受牙齿疼痛和肿胀的困扰。他们中的一些人：

- 无力进行定期口腔检查。
- 由于疾病或医源性（如器官移植等）因素引起免疫功能低下。

Pulp and periapical infection should not be trivialised and should be treated early and well. Whilst the majority of affluent, dentally aware, fit and healthy individuals probably regard dental sepsis as the stuff of comic cartoons, a significant number of individuals still experience pain and swelling of endodontic origin. Some of these:

- do not have ready access to routine affordable dental care
- are immunocompromised by disease or iatrogenically (e.g. following organ transplantation)

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• 机体内的微生物产生了耐药性。在此情况下，牙源性感染可能会引起全身的严重感染（图2-1）。

牙髓炎和根尖周炎通常可分为以下几种：

• 症状性牙髓炎（可复性及不可复性）
• 症状性根尖周炎（局限性及扩散性）

症状性牙髓炎

牙髓中含有来自三叉神经的丰富感觉神经纤维，其中大多数神经末梢为痛觉神经，与患者的不适和疼痛有关。

分布在牙髓外围的是Aδ纤维神经末梢（图2-2），它具有以下特征：

• may be in danger of infection from antibiotic-resistant microorganisms and can be seriously compromised by dental infection (Fig 2-1).

Common scenarios will be considered under the headings:

• Symptomatic pulpitis (reversible and irreversible)
• Symptomatic apical periodontitis (contained and spreading).

Symptomatic Pulpitis

Dental pulps have a rich sensory nerve supply from the trigeminal nerve. Most of the nerve endings are nociceptive, communicating discomfort or pain.

At the periphery of the pulp lie the nerve-endings of Aδ fibres(Fig2-2), characterised

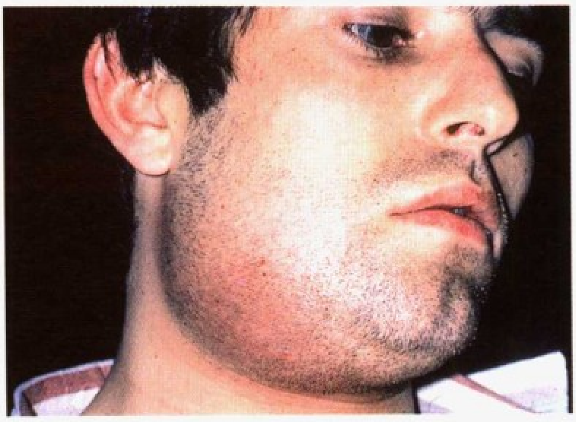


图2-1 肿胀的起因只是一个未经处理的小问题

Fig 2-1 What started as an untreated minor niggle

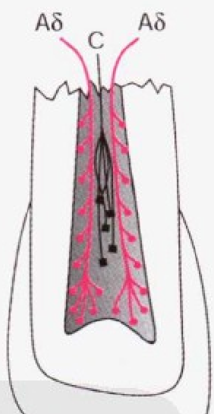


图2-2 主要痛觉神经受体的分布：快反应的Aδ纤维位于外周，而慢反应的C纤维位于中心

Fig 2-2 Location of predominant sensory pain receptors. Fast-reacting Aδ fibres lie peripherally whilst slow-reacting C fibres reside in the core

• 刺激阈值较低。
• 反应和传导迅速。
• 传递尖锐的、一过性疼痛。

牙龈退缩、牙釉质缺损、修复体脱落或边缘微渗漏、早期龋坏时，都会导致牙本质暴露于口腔，使Aδ 纤维的神经末梢受到刺激。

疼痛通常由热、冷或甜食刺激引起，当刺激去除后，疼痛立即消失。Aδ 纤维的疼痛史通常提示牙髓组织受到了表浅的、轻微的刺激，存在轻微的炎症。如果病因去除，可复性的牙髓损伤会消失。

感觉神经C 纤维位于牙髓较中心位置（图 2-2），它具有以下特征：
• 刺激阈值较高。
• 反应和传导较慢。
• 剧烈、烧灼样钝痛和阵痛。

这些疼痛是由于重度炎症扩散至牙髓中心刺激C纤维引起的。C纤维疼痛通常晚于Aδ 纤维，平常所说的"牙痛"即为C纤维的疼痛，热、冷或甜食刺激均能引起C纤维疼痛，但与Aδ 纤维不同，当刺激去除后，C纤维疼痛不会立即消失，而往往会持续几分钟。它还常表现为自发痛，典型表现为在没有冷热等刺激物的情况下出现可使患者痛醒的夜间自发痛。C纤维疼痛史往往提示牙髓可能已经发生了严重的、

by:
• low threshold of stimulation
• fast reaction and conduction
• communication of sharp, fleeting pain sensation.

These are the fibres stimulated when dentine is exposed to the mouth by gingival recession, traumatic loss of enamel, lost or leaking restorations, or early dental caries.

Pain is usually stimulated by hot, cold or sweet foodstuffs and disappears as soon as the stimulus is withdrawn. A history of Aδ pain usually indicates superficial and minor irritation or inflammation of the pulp; reversible injury which will resolve if the insult can be removed.

More centrally placed are sensory C fibres (Fig 2-2), characterised by:
• high threshold of stimulation
• slow reaction and conduction
• communication of heavy, dull, intense pain, often throbbing in nature.

These are the fibres stimulated by serious inflammation spreading deep into the centre of the pulp. C-fibre pain is often preceded by Aδ pain, and is the classic "toothache". It can be stimulated by hot, cold and sweet foodstuffs, but unlike Aδ pain, it does not disappear immediately after the stimulus is withdrawn, and will often linger for minutes. It can also appear spontaneously, classically waking patients at night when there is no stimulus in the

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不可逆的炎症。

mouth to provoke it. A history of C fibre pain indicates serious and probably irreversible damage to the pulp.

症状性牙髓炎的诊断难点

Symptomatic Pulpitis - Diagnostic Challenges

• 隐蔽性。

和手指上的炎症不同，牙髓炎的患牙定位和病变情况不能通过直接的视诊而获得。龋坏的存在、修复体的脱落或边缘渗漏可供参考，但不能作为确诊的依据。

• You cannot see it.

Unlike an inflamed finger, the location and condition of a symptomatic pulp can not be diagnosed by direct visual inspection. Circumstantial evidence may come from the presence of caries or a lost or leaking restoration, but often the culprit is far from clear.

• 不能自行定位。

牙髓没有本体感受神经纤维，患者通常只能指出疼痛位于口腔的一侧；有时患者能正确指出患牙，有时则误以为是有治疗史或疼痛史的牙齿。同侧上下颌牙齿的混淆在临床上很常见（图 2-3）。在疼痛定位中医师经常会由于粗心或过度相信患者的主观感觉而被误导。

• The patient cannot locate it.

Pulps have no proprioceptive nerve fibres. Usually symptoms are experienced in a general area on one side of the mouth; sometimes pinpointed by rationalisation or referral to a tooth which was treated or troublesome in the past. Referral between the maxilla and mandible on the same side of the mouth is common (Fig 2-3). The unwary or unduly trusting are easily caught out.

• 在检查中需诱发牙髓疼痛症状。

理想的检查条件是患者在检查前几小时内未服用止痛药。检查时应选用合适的刺激。由于病人很少有电刺激痛的经历，因而几乎不将牙髓电活力测试仪用于牙髓炎的定位和定性诊断；可选用热诊和冷诊试验，随机逐个检查疼痛区牙齿，诱发牙髓疼痛症状。

• Pulpal pain must be reproduced.

Ideally, the patient will not have taken analgesics in the hours before presentation, and an appropriate stimulus should be applied. Patients rarely give a history of "pain on electronic stimulation" and the electronic pulp tester has little or no place in diagnosing the location or state of a

冰条（图 2-4）冷诊的重复性好、准确性高，是一种经济实用的检查方法。可用于检测较厚的修复体或牙本质下方的牙髓状态。由于进行单个牙的隔离较费时，因此用热水来进行热刺激难以实现。

symptomatic pulp. Thermal challenges should be applied, either cold or hot, and walked in random order from tooth to tooth in an effort to reproduce symptoms. Pulps under large restorations or thick dentine can be difficult to challenge, and ice-sticks (Fig 2-4) provide a reproducible, profound, durable and inexpensive method. Time usually rules out individual tooth isolation and bathing with a jet of kettle-hot water.

隐裂牙的牙髓炎往往难以诊断，这种患者常有间歇性的温度敏感痛和咀嚼痛史，叩诊可无不适。通常可通过咬楔形装置（图2-5）来诱发牙髓症状：它可使裂纹发生弯曲，引起牙本质内

Teeth with enamel-dentine cracks and symptomatic pulpitis are often particularly challenging to diagnose, with sporadic, inconsistent histories of thermal sensitivity and pain on chewing, which does not re-

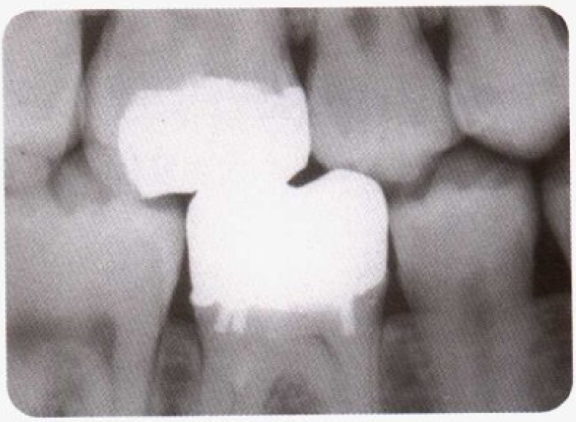


图2-3　疼痛定位不明：本病例中由于下颌第一磨牙曾经在10年前出现过疼痛并行牙髓切断术，因此易将疼痛认定为该牙，而实际上病灶牙为上颌第一磨牙

Fig 2-3　Poor pain location. Symptoms were rationalised to a lower first molar which was painful and painfully pulpo-tomised a decade earlier. The offending tooth was actually the opposing upper first molar

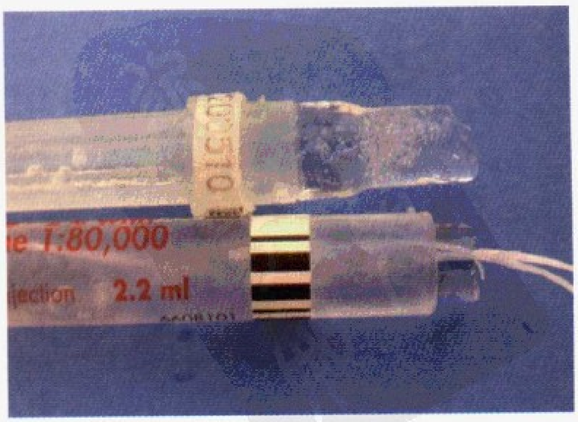


图 2-4　冰条由局麻针筒及丝线或针套制成。冷诊试验是一项经济实用、重复性好的诊断方法，但应注意避免针筒或针套的交叉感染

Fig 2-4　Ice-sticks made from local anaesthetic cartridges and floss, or needle sheaths provide an inexpensive, durable and reproducible cold challenge. Used cartridges or sheaths present cross infection risks and should be avoided

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图 2-5 Tooth sleuth 是商品化楔形装置中的一种，可使隐裂处的牙体硬组织移位，引起牙本质小管中液体的运动，并刺激Aδ 痛觉神经，诱发牙髓敏感症状从而检测出牙隐裂

Fig 2-5 Tooth sleuth, one of several commercial wedging devices for the displacement of incomplete tooth fractures and reproduction of pulp sensitivity due to fluid movement in the crack and Aδ nerve stimulation

液体的流动，从而引起疼痛。当松开咬合时，移位的牙尖迅速复位，此时疼痛症状最为明显。

ally represent tenderness to percussion. Their pulpal symptoms can often be reproduced by biting on a wedging device (Fig 2-5), which forces crack flexion, movement of dentine fluid and pain. Symptoms are often most profound on release of biting pressure as the displaced cusp recoils rapidly.

可复性牙髓炎

可复性牙髓炎具有温度敏感的病史，表现为一过性锐痛，疼痛难以定位（A δ 纤维疼痛），临床检查可诱发。如果去除病因，阻止炎症扩散，牙髓将恢复健康。

Reversible Pulpitis

Reversible pulpitis is characterised by a history and clinical reproducibility of sharp, transient, poorly localised thermal sensitivity (Aδ fibre pain). If the cause is removed, and extension prevented, the pulp should return to health.

去除病因

龋坏及不良修复体应予去除。如果是隐裂，最好通过透视法或染色法检查。去除隐裂处的牙体组织，并用修复材料修复。

Remove the cause

Caries or defective restorations should be removed. If the cause is a crack, its course should be investigated, ideally with transillumination and stains. Undermined, flexing cusps should be removed for overlay with restorative material.

防止扩散

封闭窝洞，以防止细菌和唾液进入。简单的氧华锌丁香油粘固剂封闭就可使超过95%的患者症状减轻，但应用树脂粘结剂封闭窝洞是否会得到更好的效果，目前尚不清楚。

永久修复应在牙髓炎症状消失后进行，需密切观察是否有不可复性牙髓炎、牙髓坏死及根尖周炎症状出现。

Prevent extension

The cavity should be sealed, bacteria- and fluid-tight. More than 95% of cases will experience relief from a simple zinc oxide-eugenol cement dressing. It is not currently known if the outcome is better following cavity sealing with a resin bonding agent.

Definitive restoration can be arranged after symptoms have resolved, and the tooth should be monitored for signs and symptoms of irreversible pulpitis or pulp necrosis with apical periodontitis.

不可复性牙髓炎

不可复性牙髓炎具有激发痛、自发痛、温度刺激引起的剧痛和延缓痛的病史，临床检查可诱发此类疼痛（C纤维疼痛）。无论采取何种治疗方法，牙髓都不能恢复到正常状态，但可阻止炎症继续扩展。

Irreversible Pulpitis

Irreversible pulpitis is characterised by a history of provoked and spontaneous dull, heavy and lingering thermal pain which can be reproduced clinically (C fibre pain). Regardless of operative efforts, the pulp cannot return to health, but extension can and should be prevented.

去除病因

进入髓腔之前，应在局麻下去龋及拆除不良修复体。

Remove the cause

Caries and defective restorations should be removed under local anaesthesia, before entry into the pulp chamber.

引　流

去龋时的穿髓孔有时可作为牙髓脓肿引流非常理想的排脓途径，有利于进一步明确诊断并使疼痛大大缓解。

Drain

Occasionally, pulp exposure during initial excavation yields a very satisfying discharge of pus from a pulp abscess, reinforcing a correct diagnosis and bringing substantial pain relief.

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防止扩散

最可靠的缓解疼痛和防止炎症扩散的方法是完全去除牙髓，彻底清洁和修整根管系统。在应急处理中可能出现下列情况：

- 麻醉困难。
- 时间有限而无法全部完成。

Prevent extension

The most reliable way of relieving pain and preventing extension is to remove the entire pulp and thoroughly clean and shape the canal system. In an emergency:

- anaesthetic difficulties
- limitation of time may rule this out.

麻醉困难

大多数局部麻醉失败都是由于麻醉药物注射的位置不准或剂量不足造成的。但在急性牙髓炎中，即使麻醉药物注射的位置准确、剂量也足够，有时仍无法获得满意的麻醉效果，这可能是由于与炎症相关的外周神经膜电位发生改变，使它们能够耐受麻醉药物，或者提高了疼痛的阈值。麻醉失败在牙科中很常见，但机制尚不十分明确，这也是导致人们害怕牙髓治疗的原因之一。

Anaesthetic Difficulties

Most failures of local anaesthesia are due to inaccurate deposition or an inadequate dose of anaesthetic agent. In the case of the "hot" pulp, anaesthesia may not reach effective working levels despite profound anaesthesia of related structures. Explanations include changes in the membrane potential of inflammation-associated peripheral nerves, rendering them resistant to anaesthesia, or central heightening of sensory perception. Failed anaesthesia is a major and poorly understood issue in dentistry, and one which continues to reinforce public apprehension of endodontic procedures.

麻醉困难的处理

麻醉失败的处理方法有：

- 增加麻醉药物有效剂量。
- 阻断神经传导的替代通路。
- 更换麻醉药物。

增加有效药物剂量包括重复进行

Dealing with anaesthetic difficulties

Approaches to failed anaesthesia include

- increasing the effective dose
- targeting or circumventing alternative routes of innervation
- use of an alternative agent.

Increasing the effective dose may involve

浸润或阻滞麻醉，或将药物注射位置更靠近神经的近端（如Akinosi 阻滞麻醉），但注意不要超过药物的剂量。对于上颌磨牙，浸润麻醉可以注射于单独的牙根（近颊根、远颊根和腭根）附近，对下颌磨牙，颊长神经阻滞麻醉加根尖处舌侧薄骨板骨膜下浸润麻醉可收到很好的效果。骨内注射可以作为有效的补充，其包括：

- 牙周膜浸润麻醉。
- 牙槽中隔浸润麻醉。
- 在牙根颊侧骨皮质上钻孔后注入麻醉药。

有时可将麻药直接注入牙髓组织，这种麻醉方法不依赖于麻药的种类，而主要是通过对牙髓神经的高压冲击而起作用。此种麻醉在进针时会产生瞬间疼痛，因此需要病人的良好配合。但注入后可立即生效，为快速进入或去除牙髓组织提供良好的麻醉效果。

尽管利多卡因和肾上腺素仍然是局麻药物的金标准，其他药物，如阿替卡因，在麻醉困难的病例中可依赖其强渗透性而发挥作用。

时间限制

由于时间受限，在应急处理中，医生只能选择较少的治疗步骤。牙髓治疗方法依疼痛缓解的有效性由大到小

repeating an infiltration or block, or delivering it higher (e.g. Akinosi block) but mindful of the toxic limits of the agent in use. In the case of a maxillary molar, infiltrations may be targeted at individual roots (mesiobuccal, distobuccal and palatal), and for mandibular molars, blocking the long buccal nerve and infiltrating beneath the periosteum of the thin lingual plate over the tooth apices may be helpful. Intraosseous injections in the form of:

- periodontal ligament infiltration
- intraseptal infiltration
- delivery though a puncture hole in the buccal cortical plate may also be potent supplements.

Sometimes it is necessary to infiltrate directly into pulp tissue, which operates by high-pressure concussion of pulpal nerves and is independent of the anaesthetic agent. This transiently painful method demands the good will of the patient, but acts almost immediately to allow rapid entry and removal of pulp tissue.

Whilst lidocaine and epinephrine remains the gold-standard local anaesthetic agent, alternatives, notably articaine, may offer greater penetration in difficult situations.

Limitation of Time

Time often forces a lesser procedure, in order of pain-relieving reliability:

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排列：

- 全部牙髓摘除术
- 冠髓切除术（牙髓切断术）
- 扩大牙髓穿孔及暂封

龋坏的去除和窝洞的严密封闭，在缓解疼痛上胜于某些配方精确的止痛药。不过抗生素／类固醇药物Ledermix™和其他多种固化和非固化型氢氧化钙类药物在英国仍被广泛使用。

- gross pulp extirpation
- coronal pulp amputation (pulpotomy)
- wide pulpal exposure and dressing.

Pain relief is related more to caries removal and tight sealing of the cavity than to the precise composition of any "obtundent" medication. The antibiotic/steroid preparation Ledermix™ and various setting and non-setting calcium hydroxide preparations are popular in the UK.

采取上述治疗方法后，90%以上病例的疼痛都会得到缓解。单独应用抗生素不能立即缓解疼痛，不能作为牙髓炎的处理方法。

Pain relief will be secured in more than 90% of cases provided that something operative is done. Antibiotics alone will offer no relief in the immediate term and have no place in the management of symptomatic pulpitis.

症状性根尖周炎

症状性根尖周炎的特征如下：

- 牙髓部分或全部坏死。
- 咀嚼或牙齿运动时疼痛。
- 牙齿有浮出感。
- 由于累及的牙周膜有丰富的本体感觉神经末梢，患者能够准确定位患牙。

Symptomatic Apical Periodontitis

Symptomatic apical periodontitis is characterised by:

- a dead or dying pulp
- pain on chewing or tooth movement
- a pressurised sensation of the tooth rising in its socket
- fine localisation by the patient as the affected periodontal ligament is richly supplied with proprioceptive sensory nerve endings.

新病例的产生多来源于有多次修复史的患牙，或者是由龋和创伤导致的牙髓感染和崩解所引起，其中许多病例是由于宿主与感染之间的平衡被

New cases arise in teeth with cumulative restorative histories, or which have undergone pulp infection and breakdown after caries or trauma. Many also represent acute

打破而引起的，表现为无痛性慢性病损的急性发作（图 2-6）。

症状性根尖周炎之所以重要是因为：

- 可引起局部疼痛、肿胀等。
- 如出现炎症扩散，可引起严重后果。

exacerbations of painless, chronic lesions signifying a shift in the host/infection balance (Fig 2-6).

Symptomatic apical periodontitis is important because of the:

- local pain, swelling and suffering that it causes, and the
- potentially serious consequences of extension.

局限性症状性根尖周炎

在局限性炎症中，炎症可被局限在骨内（此时没有局部肿胀），或伴有局部的肿胀。病人淋巴结可有肿大，但通常感觉良好，无体温升高症状。病灶牙可通过以下临床表现定位：

- 局部肿胀（图 2-7）。
- 牙髓敏感性测试呈阴性：牙髓电

Contained Symptomatic Apical Periodontitis

In the contained situation, inflammation may be confined within bone (no local swelling), or associated with a circumscribed area of swelling. The patient may have enlarged local lymph nodes but feels generally well and does not have a raised temperature. The offending tooth is identified by:

- the presence of a localised swelling (Fig 2-7)
- negative pulp sensitivity testing. Here



图2-6　有多次修复病史的患牙，长期慢性病变急性发作

Fig 2-6　Acute exacerbation of a long-standing, silent lesion present on a repeatedly restored and crowned tooth

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图 2-7 局限性急性根尖周炎的局部肿胀，患者全身情况良好

Fig 2-7 Circumscribed swelling in contained acute apical periodontitis. The patient is systemically well

活力测试仪可协助诊断，但应清楚根尖周炎的牙中可有残髓，多根牙各个牙根中的牙髓状态可能不同。

- 咬合痛或轻叩痛：叩诊或用指尖轻压均足以引发疼痛反应。
- X线片显示根尖或侧方有骨质缺损。

应急处理时，需牢记引起临床症状的感染主要位于患牙根管内，根尖周的改变是对这种局限性感染的反应。

the electronic pulp tester adds to the diagnosis, remembering that apical periodontitis can be present in teeth with remnants of living tissue, and that multi-rooted teeth may contain tissue in different states

- tenderness on biting or gentle percussion. Percussion or pressure with a finger tip is often sufficient to provoke a response
- radiographic signs of apical or lateral bony rarefaction.

During immediate treatment, it should be remembered that the infection causing symptoms is contained in the pulp canal of the offending tooth; the periapical changes are a response to this contained infection.

无软组织肿胀

去除病因

在局麻和橡皮障隔离患牙的情况下开髓，清理、冲洗根管，最好进行彻底地根管清洁和成形。

No Soft Tissue Swelling

Remove the cause

Open the tooth under local anaesthesia and rubber dam, clean and irrigate the canals. Ideally the canals should be fully cleaned and shaped.

引　流

有时根尖周脓肿会因为脓液的压力而自发破溃引流。如果用不超过25号的锉插入并稍超出根尖孔，轻微旋转扩大根管口，则更利于引流。大多数情况下，患者已进行过根管治疗，此时脓液无法顺利通过根管引流，需将皮质骨钻孔以建立通畅引流来减压（图2-8）。

防止扩散

通过根管预备可有效防止感染扩散，但紧急情况下不宜使用。抗生素——氢氧化钙或类固醇——抗生素糊剂有助于控制根管内感染，糊剂可附着在用来防止根管阻塞的棉捻上，然后用3mm厚的水门汀暂封。需特别注意避免棉絮粘附在洞型的边缘，否则带菌的唾液会渗入根管内。

Drain

Sometimes spontaneous drainage occurs from a pressurised focus of periapical pus. This can be encouraged by apical trepanation with a file no larger than size 25, gently inserted beyond the root-end. There are rare occasions in teeth not previously root treated in which discharge cannot be secured through the canal, and the cortical plate must be punctured with a bur to release pressure and secure discharge (Fig 2-8).

Prevent extension

Extension is best prevented by thorough canal preparation, but this may be limited in an emergency situation. An antimicrobial calcium hydroxide or steroid-antibiotic paste may help to control intracanal infection, sealed in place with a cotton pledget to guard against blockage of canal entrances, and a 3mm thickness of well-

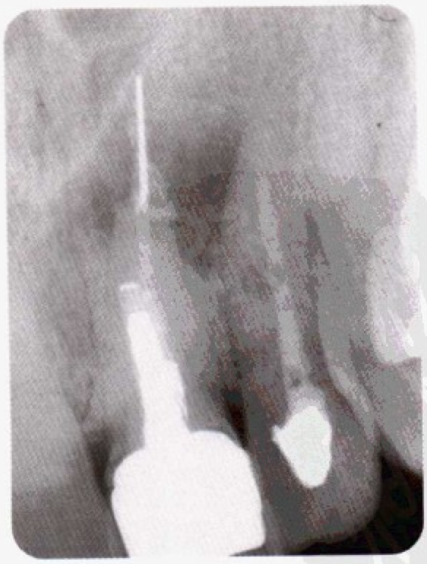


图2-8　根管已经充填，无法通过便捷的根管开放来缓解疼痛，需要在皮质骨钻孔以建立引流来减压

Fig 2-8　Cortical trepanation may be needed to drain and relieve pressure from a painful lesion which cannot be simply liberated through the canal. A rare event in teeth not previously root-treated

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adapted cement dressing. Special care should bc taken to avoid the presentation of cotton wool fibres at the cavity margins, which may wick infected saliva into the tooth.

支持治疗

可采用以下辅助措施来减轻疼痛，促进愈合：

- 调𬌗：患牙𬌗力过大会加重根尖周炎的疼痛。
- 保证充足的营养和水分：牙痛的患者往往忽视正常的进食和饮水。
- 止痛：当压力减轻后疼痛通常会迅速缓解，但如果仍有持续性不适，建议服用普通非类固醇消炎药物。还可通过定期服用不同类型的止痛药，如扑热息痛（对乙酰氨基酚）和布洛芬来止痛，并可避免因过量服用一种药物而引起的药物中毒。
- 抗生素：抗生素不能代替治疗。下列情况下不应使用抗生素：已进行开髓和根管清洗的患者；身体状况良好、没有免疫功能低下

Supportive therapy

Standard measures can be supplemented to aid pain relief and recovery:

- Relieve the occlusion. There is no surer way to exacerbate periapical pain than to leave an extruded tooth in heavy occlusion.
- Ensure adequate nutrition and hydration. Patients with toothache frequently neglect to eat and drink properly.
- Analgesia. Pain relief usually follows rapidly once pressure has been relieved, but patients with persistent discomfort should be advised to use normal non-steroidal inflammatory drugs if needed. Dissimilar agents such as paracetamol (acetaminophen) and ibuprofen can be taken regularly at staggered intervals to avoid troughs in analgesia, and without risk of toxicity associated with overuse of individual agents.
- Antibiotics. Antibiotics should not be used as a means of avoiding surgical intervention. They should not be prescribed if the tooth can be opened and

的患者; 随后几天内患者有时间复查。但对于可能发生感染性心内膜炎的患者,应急处理时应使用抗生素。

cleaned, if the patient is generally well and not immunocompromised, and if it will be possible to make contact with them during the following days. Patients at risk of infective endocarditis should be covered for acute endodontic procedures of this sort.

局部软组织肿胀

和无软组织肿胀的症状性根尖周炎的处理方法一致。需强调的是,尽管出现软组织肿胀, 病因仍然是患牙内部的感染。

Local Soft Tissue Swelling

Management follows the same pattern as described for symptomatic apical periodontitis with no soft tissue swelling. It should again be emphasised that despite the presence of a soft tissue lesion, the cause is still infection inside the offending tooth.

需要考虑的其他问题

开放引流

根管引流有时可持续数分钟, 可让患者坐在安静私密的地方, 轻轻地吮吸患牙, 此法有助于吸出根管内引流物。目前还不清楚牙齿开放引流是否会对最终的伤口愈合产生严重影响,但开放引流有可能将食物残渣挤出根尖孔, 引起难以处理的异物反应及顽固性感染。因此,保持牙齿开放引流的状态是一种很少采用的极端做法, 且开放不宜超过24h,随后应清洁并封闭根管。

Additional considerations

Open drainage

Drainage through the root canal may occasionally persist for many minutes. This can usually be dealt with by asking the patient to sit in a quiet and private area for a few minutes with a disposable cup as the tooth continues to discharge. Gentle sucking on the tooth may help. Whilst there is little evidence that leaving teeth open for drainage has a serious impact on eventual healing, this practice can be associated with intractable foreign body responses to food debris impacted beyond the root-apex and anecdotally with refractory infection. Leaving teeth open for drainage is an occasional, extreme measure, continued for no more

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than 24 hours before canal debridement and closure.

软组织切口

即使已开放根尖孔并辅以根尖外部的轻柔挤压，也不一定能将所有的脓液通过根尖孔引流出来。在这种情况下，可在阻滞麻醉、浸润麻醉、表面麻醉或涂氯乙烷后切开有波动感的肿胀软组织。根据局部解剖结构，用手术刀片切开肿胀最明显的部位，用止血钳钝性分离，建立通畅引流。对于口内引流，一般不主张放置橡皮引流条，可让患者经常用温盐水漱口，保持引流通畅。

Soft-tissue incision

Not all pus will drain through a root canal, even with apical trepanation and gentle external pressure to encourage it. In these situations, the fluctuant soft tissue swelling should be incised under block or distant infiltration local anaesthesia, or following topical anaesthesia with gel or a jet of ethyl chloride. The most dependent point of the swelling should be punctured with a scalpel and due regard for local anatomical structures. Discharge can be assisted by blunt dissection with a haemostat, which is introduced closed, opened in the wound, and withdrawn open to avoid trapping tissues. There is little evidence to support the use of rubber drains for intraoral sites, which can be encouraged to remain open and discharge with frequent warm salt water mouthwashes.

抗生素和止痛药

在建立了通畅引流和去除感染后，对全身健康状况好、没有免疫功能低下的患者可不予用药。而在不能建立良好引流的情况（如在颏神经区域），则需使用抗生素。

一般根据经验使用药物，原则是

Antibiotics and analgesics

Drugs are seldom indicated for well, immunocompetent patients after drainage and elimination of infection. However, there may be occasions where satisfactory drainage is not secured (e.g. in the region of the mental nerve), and the use of antibiotics is supported.

Prescribing is empirical, with the empha-

时间短、药效强，并每日询问病情。

sis on short, sharp courses and daily patient contact or review.

经验处方（包括根尖周炎）：

Empirical prescribing (contained apical periodontitis)

首次口服阿莫西林 3g；8h 后再次口服阿莫西林 3g，或 250mg，4/d，连服 5d。

3g amoxicillin orally, loading dose; PLUS further 3g amoxicillin orally 8 h later, or 250mg qds for 5 days.

对青霉素过敏的患者应采用：

Penicillin-allergic patients should receive:

红霉素 250mg 或克林霉素 150mg，4/d，连服 5d。

erythromycin 250mg or clindamycin 150mg qds for 5 days

如效果不佳，均可再增加甲硝唑 200mg，3/d，连服 5d。

Either of these regimes can be supplemented by metronidazole 200mg tds for 5 days, if monitoring and further surgical intervention fail to demonstrate satisfactory progress.

扩散性症状性根尖周炎

Spreading Symptomatic Apical Periodontitis

在扩散性症状性根尖周炎的进程中，微生物可从根管系统侵入头颈部筋膜间隙，有时可引起严重威及生命的疾病，如 Ludwig's 咽峡炎、纵隔炎、海绵窦血栓或脑脓肿。这些病人往往全身情况较差，并伴有高热（图 2-9）。

In the advanced stages of spreading symptomatic apical periodontitis, microorganisms may migrate from the root canal system and track through the fascial spaces of the head and neck, occasionally causing serious and life-threatening disorders such as Ludwig's angina, mediastinitis, cavernous sinus thrombosis or brain abscess. These patients are often systemically unwell and have an elevated temperature (Fig 2-9).

同样，感染灶依然是牙髓。因此，应在疾病发展到此阶段之前，正确诊

The primary focus of the infection is again the infected contents of a tooth. En-

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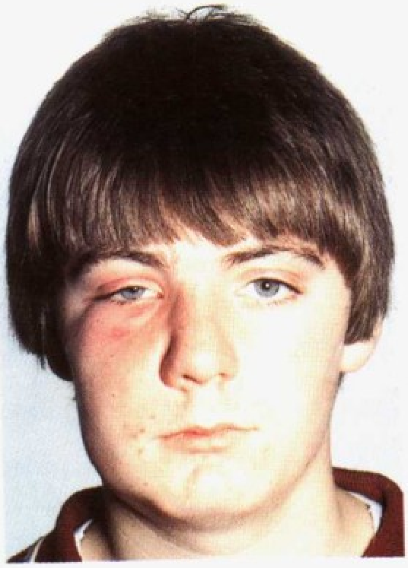


图2-9 一例牙髓感染扩散的病例。在抗生素出现之前，这种患者的预后可能很差

Fig 2-9 An unwell patient with spreading infection of endodontic origin. In the pre-antibiotic era, the prognosis may have been grave

治患牙的牙髓感染。

dodontic infections should ideally be diagnosed and properly treated before this stage, when management along conventional guidelines may be difficult.

去除病因

出现严重扩散性感染的患者，往往张口受限。此时，对患牙的诊断、开髓、去除感染物等处理都很困难，拔牙也同样困难。

Remove the cause

In patients with serious, spreading infection, mouth opening is often limited and it can be very difficult to diagnose, open and manage infection in the offending tooth. Extraction can be equally difficult.

引　流

在感染灶局限之前，由于没有明显的波动感，切开位置不易掌握，因此切开引流比较困难。

Drain

Spreading infections are difficult to drain until they have become localised, with no fluctuation to incise and the temptation to incise into tissues whose surgical anatomy is not frequently remembered.

防止扩散

应用常规的大剂量抗生素防止炎

Prevent extension

Extension should be prevented by the

症扩散，同时要避免面部的热敷，以免感染向颌面部间隙中扩散，还需静养休息。

empirical prescription of high-dose antibiotics, the avoidance of warm facial compresses which may promote extension through the facial tissues, and the avoidance of physical exertion.

经验处方（扩散性感染）：

Empirical prescribing (spreading infections)

首次口服阿莫西林 3g；然后服用阿莫西林 500mg，4/d，连服 5d；或甲硝唑 200～400mg，3/d，连服 5d。

3g amoxicillin orally, loading dose; PLUS amoxicillin 500mg orally qds for 5 days; PLUS metronidazole 200-400mg orally tds for 5 days.

对青霉素过敏的患者应用：

Penicillin-allergic patients should receive:

口服红霉素 500mg，4/d，连服 5d 或克林霉素 300mg，4/d，连服 5d；同时服用甲硝唑 200～400mg，3/d，连服 5d。

erythromycin 500mg qds for 5 days or clindamycin 300mg qds for 5 days; PLUS metronidazole 200-400mg orally tds for 5 days.

其他支持治疗包括补充足够的体液和营养，至少每日复诊一次以观察病情。

Supportive therapy includes adequate fluid and nutritional intake, and at least daily contact to assess progress.

大多数炎症数天后可以局限，此时可进行根管处理，对有波动感的软组织可切开引流。有时炎症仍然可能扩散，则需要去医院治疗。

Most lesions will localise within days to become contained and amenable to pulp canal entry and incision and drainage of a circumscribed soft tissue fluctuance. Some will not.

需要立即转至医院治疗的危险体征：

- 吞咽困难。
- 呼吸困难。
- 口底抬高／变硬。
- 病变累及软腭。

Warning Signs which Indicate Immediate Referral to Hospital

- dysphagia
- respiratory difficulty
- raised/stiff floor of mouth
- soft palate involvement

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- 视力受损／眼球运动障碍。
- 声音嘶哑。
- 精神较差。
- 意识障碍。
- 脱水／营养不良。
- 体温 39℃。

入院治疗包括：

- 根据经验通过静脉给予特定抗生素。
- 保持呼吸道通畅。
- 体液和营养支持。
- 病变区引流，去除病灶。
- 密切监护。

目前此类严重的并发症已很少发生，但应牢记牙齿内的细菌感染有可能引发此类疾病。

- impared vision/eye movement
- hoarseness
- lethargy
- impaired consciousness
- dehydration/malnutrition
- temperature of 39℃.

Hospital admission will allow

- empirical, followed by specific intravenous antibiotics
- airway protection
- fluid and nutritional support
- drainage of affected sites and removal of the source
- close monitoring.

Mercifully, such serious events are currently rare, though it should never be forgotten that the process leading to this end begins with the entry of oral microorganisms to the pulp space.

结　论

- 对症状性牙髓炎和根尖周炎应引起足够重视。
- 疾病通常由髓腔内的细菌感染引起。
- 通过在临床上诱发疼痛症状来进行诊断。
- 对健康的、免疫力正常的患者而言，应急处理应根据外科处理原则，而不是首先使用抗生素。
- 及早治疗以避免炎症扩散后危

Conclusions

- Symptomatic pulpitis and apical periodontitis should not be trivialised.
- Disease is usually caused by microorganisms contained within the pulp space.
- Diagnosis is based on reproducing presenting symptoms.
- Immediate care is based on established surgical principles with little or no role for antimicrobial drugs in healthy, noncompromised patients.
- Lesions should be treated early to

及生命。

minimise the risk of more serious extension which can occasionally be life-threatening.

拓展阅读
Further Reading

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第3章 治疗前的准备工作

Preparing for Definitive Treatment

目 的

讲述对需要进行根管治疗的患牙进行评定的注意事项，介绍一些术前准备工作，如局部麻醉，𬌗调整和简便的橡皮障隔离等方法。

Aim

To introduce important issues in the assessment of a tooth for definitive root canal treatment and describe preparatory measures including the need for local anaesthesia, occlusal adjustment and simple methods of rubber dam isolation.

要 点

通过学习此章，应对准备进行的根管治疗术计划中，有关整体和局部的问题有清楚的了解，并认识到橡皮障隔离等准备工作的必要性。

Outcome

After studying this chapter, the reader should have a clear view of general and local issues in planning definitive root canal treatment and understand the value of rational preparatory measures including rubber dam isolation.

患牙的应急处理在第二章已经叙述，接下来讨论应急处理之后的治疗方法。

The immediate management of symptomatic teeth was described in Chapter 2. In subsequent chapters, it will be assumed that acute symptoms have been controlled.

根管治疗并非治疗过程中的全部内容

目前的技术使医师能够进入所有牙齿的根管系统并进行充填，但这并

Not Everything That Can Be Root Treated Should Be

Current techniques make it possible to access and root fill just about any tooth, but

不意味着所有患牙都需要进行根管治疗。根管治疗术不是孤立存在的，它仅是整个治疗计划中保存修复患者的一种方法。

that does not mean that all damaged teeth should be. Root canal treatment must never be an isolated technical exercise; it is simply a means of preserving teeth for restoration within the context of a holistic treatment plan.

治疗计划中应考虑到以下问题：

- 患牙在整个治疗计划中的作用？
- 患牙是否可以修复？
- 治疗过程中的感染是否可以控制？
- 在衡量患牙需要进行根管治疗还是拔除时，是否还要考虑其他的因素？

The following questions should be asked:

- What is the role of the tooth within a broader plan of care?
- Is it restorable?
- Can I control infection in it?
- Are there any additional factors which weigh the case for root canal treatment or extraction?

治疗计划应该考虑患者的临床表现、现病史、检查结果、近期高质量的X线片以及患者的期望值和经济能力。即使患者已经拍摄了大的口外片，仍需拍摄小的根尖片，以便详细了解病情。拍片时，应该采用平行投照技术，使影像尽可能地接近牙齿的真实大小（图 6-9）。

Decisions should be based on clinical and medical history, clinical examination and recent, good-quality radiographs as well as patient aspirations and finances. Even if large extraoral films have been exposed for general planning, small intraoral films are often justified for greater detail. Images should be projected as near to actual size as possible by the use of a paralleling device (Fig 6-9).

患牙在整个治疗计划中的作用

What is the Role of the Tooth Within a Broader Plan?

应考虑以下问题：

- 是否值得牺牲一颗磨牙来缩短牙弓？
- 保存最后一颗磨牙是否可以避

Questions might include:

- Is there merit in sacrificing a molar as part of a planned shortened dental arch approach to the mouth?
- Would preservation of a last standing

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免游离端义齿?

• 大面积龋坏或牙周状况不良的尖牙，即使其使用寿命有限，根管治疗后是否还可以作为覆盖义齿的基牙?

molar be highly advantageous in avoiding a free-end saddle denture?

• Would that grossly carious or periodontally compromised canine serve well if the root canal was treated as an overdenture abutment, even if its likely lifespan were limited?

患牙是否可以修复?

在没有进行全面的临床检查和X线检查之前（图3-1a），如果不了解牙齿的真实状况，不要给患者任何承诺。

拆去不良修复体并去净龋坏，确保任何部位的釉牙本质界完好无损，同时整个牙冠中无软化和感染的牙本质。继发龋常隐藏于X线阻射的牙冠下方，在临床上和影像学上仅表现为冠

Is the Tooth Restorable?

Patients should not be made promises before teeth have been properly explored and facts are known. Often that is more than just a thorough clinical and radiographic examination (Fig 3-la).

Defective restorations should be removed and caries ruthlessly excavated, ensuring that the amelodentinal junction is sound at every point, and that the entire crown is fee from soft, infected dentine. Caries is regu-

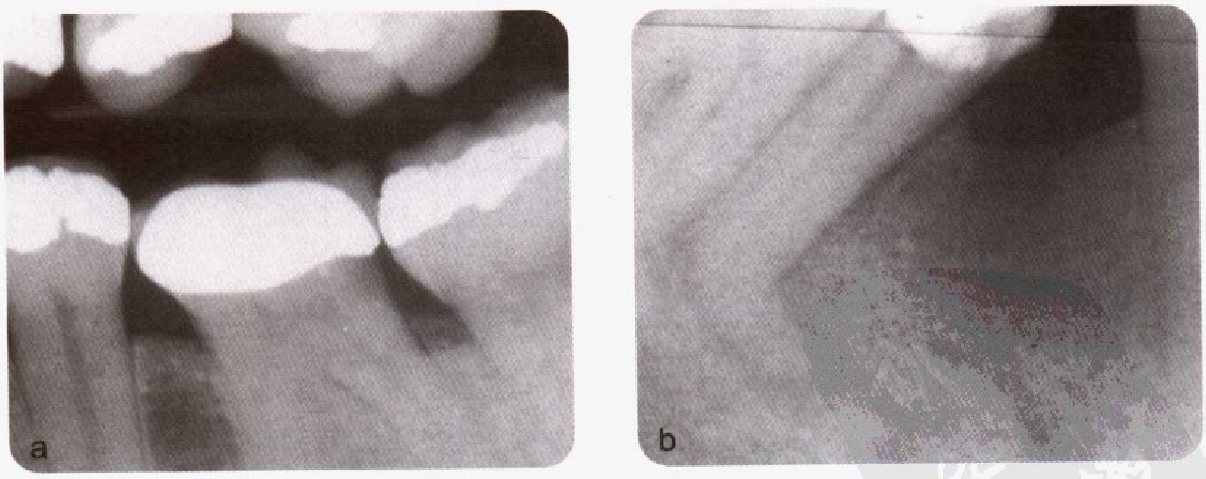


图3-1 a. 这颗患牙是否可以修复? 在给患者承诺之前是否应先去除冠和龋坏? b. 这颗牙的感染是否能够控制?

Fig 3-1 (a)Is this tooth restorable? Should the restoration and caries be removed before making any promises? (b) Can you really expect to control infection in this tooth?

边缘不密合（图3-2）。如果有疑问，最好去除修复体，去净龋坏，如果发现患牙不可修复时，应更改治疗计划。不应为尽力保留有橡皮样冠组织的患牙而忽视龋坏的去除，如果这样做不久就可能失败，而且费用很高。

larly found hiding under radiodense crowns, the only clue being a clinically or radi-ographically defective margin (Fig 3-2). If there is any doubt, it is better to remove the restoration and caries, discover that the tooth is unrestorable and make alternative plans, rather than fight through infected caries in an effort to preserve a tooth with rubber-like coronal tissue which will fail expensively before long.

通过透照法、染色法以及楔形装置等可对隐裂进行检查，若有以下情况则患牙不能保留：

- 斜行折裂若深入牙槽嵴过深。
- 松动明显的折裂片通过后牙根分叉或者前牙根部。

Teeth with cracks should be examined by transillumination, with stains and wedging devices to ensure that there are no:

- oblique marginal fractures extending deeply below the alveolar crest and which will be impossible to restore
- prominent and mobile fractures extending through furcal areas or down the roots of anterior teeth.

这样的病例即使采用了现代的结扎技术，预后仍然佳，应在一开始就告

Such cases have a compromised prognosis, even with contemporary bonding



图3-2　去除不良修复体后，发现有大量龋坏冠组织呈橡皮样

Fig 3-2　Removal of this defective crown revealed grossly carious, rubbery coronal tissue.

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知患者。

techniques, and the patient should be made aware of this fact before decisions are made.

若患牙因为任何一种原因而无法修复，再进行根管治疗只会费时费力费钱，让患者失去信心，其期望值也无法达到，因此最好从一开始就予以避免这种情况。

If a tooth is unrestorable for any reason, root canal treatment is a waste of time, effort, money, patient confidence and goodwill. It is best avoided from the outset.

治疗过程中感染能否控制？

成功的牙髓治疗意味着完全清除了根管内的感染。如果在使用了合适的橡皮障后，牙齿仍不能与口腔内的菌群隔离开来，患牙是否还可以修复？如何有效地控制感染以保证远期疗效？

根管的数目、位置、钙化程度和弯曲度也对医师提出了挑战，治疗时需考虑问题：

- 能否成功进入根管系统清除感染物质？（图 3-1b）
- 建议患者去看专科医师还是拔除？或者是向患者介绍可能遇到的困难或失败后再进行治疗？

患者张口受限会使治疗变得更加复杂。仅仅有了一定的开口度还不够，治疗所需的空间还取决于患牙的位置和角度、医师手的大小以及所采用的技术。

Can I Control Infection in It?

Endodontic success is synonymous with the elimination of root canal infection. If a tooth cannot be isolated from the oral flora with a well-fitting rubber dam, is it restorable, and can there be adequate infection control for long-term success?

Canal number, position, calcification and curvature may also present local, technical challenges and raise questions:

- Can I successfully enter this canal system and eliminate the infection (Fig 3-1b)?
- Should I recommend referral or extraction, or should I offer to treat after advising the patient on potential difficulties, and compromise?

Matters may be further complicated in patients with limited opening. Arbitrary measurements of acceptable opening are not helpful; the space necessary will depend on the position and angulation of the tooth, the hand size and techniques employed by the practitioner.

治疗计划中应考虑治疗期间感染的控制。例如，在前牙的治疗中，临时桩冠是否可以保护治疗后的残根不再受到感染？在进行永久修复前，是否需要制作临时部分覆盖义齿来保护已经封闭的根面呢？是否可以将根管治疗术和桩核冠修复一次完成（图 8-5)？

Interappointment infection control should be considered in planning. Will a temporary post crown, for example, provide satisfactory protection against reinfection in a decoronated anterior tooth, or should a temporary partial overdenture be made to cover the sealed root face until definitive obturation and restoration are possible? Alternatively, should the care be planned to complete root canal treatment and a sealing coronal post and core at a single visit (Fig 8-5)?

需要考虑的其他因素

Additional Factors Which May Weight Decision-making

医学因素

Medical considerations

根管治疗术几乎没有禁忌证。如果患者将要进行头颈部放射治疗或患者的免疫功能严重低下，这种预后不明的患牙最好拔除。

There are few medical contraindications for root canal treatment. Teeth of doubtful prognosis are probably best removed in patients about to undergo radiotherapy to the jaws or who are seriously immunocompromised.

与拔牙相反，根管治疗出血少，发生菌血症和局部损伤的危险性低于拔牙。但下列情况可能会出现这种危险性：

- 出血异常
- 罹患感染性心内膜炎患者的危险性增加
- 有头颈部放疗史

Conversely, root canal treatment carries a lower risk ofbleeding, bacteraemia and local tissue damage than extraction and may be positively indicated in patients with:

- bleeding disorders
- increased risk of infective endocarditis
- history of radiotherapy to the head and neck.

美国心脏病协会指导手册明确地将根管治疗术列为低风险的治疗，除

American Heart Association guidelines explicitly list root canal treatment as a low-

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非器械滞留在牙齿内，一般无需预防性使用抗生素。

risk procedure, requiring no antimicrobial prophylaxis, provided that instruments remain within the tooth.

社会经济因素

医师的工作环境、患者的经济状况、对牙齿保健的重视程度以及自身的意愿均可以影响医师的决定。

Socio-economic considerations

Decision-making is often critically influenced by the environment in which the dentist works, and the financial status, attitude to dental care and will of the patient.

局部麻醉

为使患者满意，在根管治疗的过程中常需进行局麻。即使X线显示牙齿有根尖周阴影或者根管系统已开放，若不实施麻醉仍无法保证治疗过程中患者的舒适。使用橡皮障进行隔离也需要对软组织进行局麻。局麻下操作有利于医师保持自信和舒适，而不至于在操作过程中为了减轻患者疼痛而中断治疗，以至于信心受挫。

目前还无法证明，在未经麻醉的情况下，可以依靠患者的感觉对根尖进行准确定位，这种方法没有任何优势可言。如何获得满意的麻醉效果在第二章已经讨论过。

Local Anaesthesia

Subject to patient consent, teeth should aways be anaesthetised for root canal treatment. Even if a tooth has a periapical radiolucency or the canal system has been opened before, there is no guarantee of comfort. Rubber dam isolation may also demand soft tissue anaesthesia. Better to be confident and comfortable than to undermine confidence and disrupt treatment by stopping mid-procedure to administer pain relief.

There is no convincing evidence that patients will reliably act as "apex locators" in the absence of local anaesthesia and there are no real advantages to be gained. Problems of satisfactory local anaesthesia were considered in Chapter 2.

殆调整

边缘嵴缺失的前磨牙和磨牙在冠部通路建立后易发生垂直方向的折裂（图3-3）。已经证明在根管治疗中，早

Occlusal Adjustment

Premolars and molars which have lost marginal ridges are especially vulnerable to vertical fracture after coronal access (Fig

接触是殆不齐的主要原因；轻微的根尖炎症可以使牙齿浮出牙槽窝，发生早接触，并形成恶性循环。如果没有特殊的殆面保护措施，最好采取以下常规方法：

- 在根管治疗前，降低后牙牙尖 1～2mm。
- 治疗后立即进行牙尖保护，即使是采用复合树脂和银汞充填这样简单的保护措施也十分有效。在允许范围内，可以牺牲小块牙体组织，以避免日后无法预料的折裂。

易折裂的牙齿通常可用合适的正畸带环或铜环来进行保护。

3-3). It is also recognised that occlusal prematurity is a principal cause of discomfort following canal instrumentation; a little apical inflammation can make the tooth rise in its socket to become proud in the occlusion, and a vicious cycle commences. Unless there are special and over-riding occlusal considerations, it is wise routinely to:

- reduce the cusp tips of posterior teeth by 1-2mm before root canal treatment
- plan an immediate cuspal-coverage restoration, even as simple as a composite resin or amalgam to protect the tooth after treatment. Better to sacrifice a little tissue in a controlled way than to suffer catastrophic, unplanned loss at a later date.

Particularly vulnerable teeth can be supported with a well-fitting orthodontic band or copper ring.

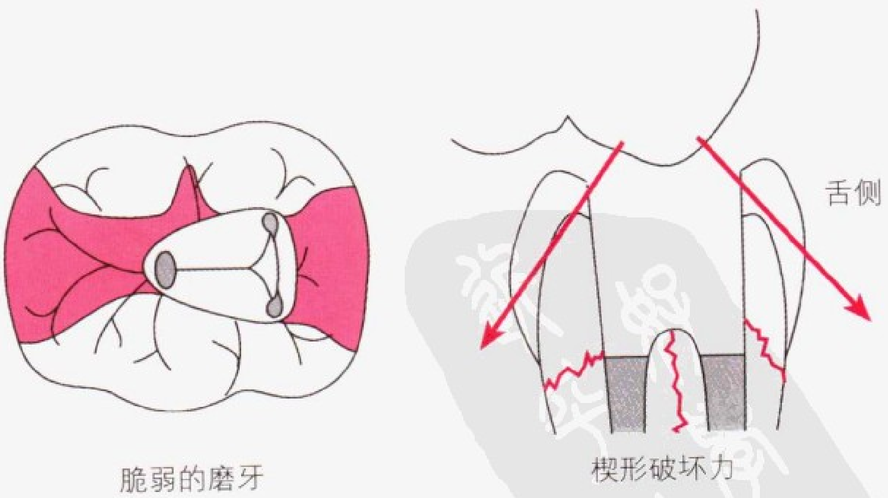


图 3-3　楔形力量可使脆弱的后牙发生折裂

Fig 3-3　The dangers of wedging forces in a weakened posterior tooth.

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橡皮障隔离

从医学法律的角度而言，所有的牙髓治疗中必须采用橡皮障隔离。它的诸多优点使它成为医师必不可少的得力助手，想要快速、安全、有效地控制感染，必须使用橡皮障隔离。橡皮障隔离的作用有：

- 防止涎液和口腔菌群进入根管系统。
- 防止器械和次氯酸钠进入口腔和咽部。
- 可使突起的软组织退缩。
- 增加患者的舒适度。
- 减少操作时间。

在一个湿滑和不断运动的口腔环境中，如果视野不好，进行根管治疗会非常困难。隔离的牙齿越少，越容易操作，渗漏也会越少。治疗中只需将单个患牙进行隔离，而无需扩大。

Rubber Dam Isolation

Medico-legally, rubber dam isolation is mandatory for all endodontic procedures. Its many advantages make it an indispensable aid, and the friend of anyone wishing to work quickly, safely, and with adequate infection control. Rubber dam isolation:

- excludes saliva and the oral flora from the canal system
- protects the mouth and oropharynx from instruments and sodium hypochlorite
- retracts intrusive soft tissues
- improves patient comfort
- reduces treatment time.

Root canal treatment can be difficult enough without adding limited visibility in a wet, slippery, mobile environment. The fewer teeth isolated, the easier it is to apply and the fewer places it has to leak. Single tooth isolation is the norm and an extensive array of equipment is unnecessary.

橡皮障夹的选择

有关特定牙位橡皮障夹的形状不再赘述。橡皮障夹应能在牙齿的最大径下方提供稳定的四点接触（图3-4）。标准的橡皮障夹盒中都有不同型号的夹子，适用于大多数牙齿（图3-5）。蝶形夹可用于前牙，但通常还需使用一小片橡胶或者 Wedjet®（Hygenic 公司）

Clamp selection

Detailed prescription of clamp patterns for specific teeth is not helpful. A clamp should provide stable, four-point contact below the maximum bul-bosity of the tooth to be isolated (Fig 3-4). A small range of clamps, available in standard kit form, is effective for most situations (Fig 3-5).

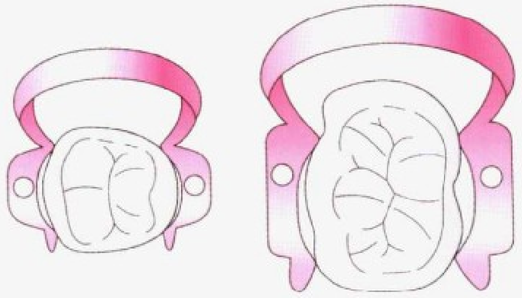


图3-4 稳定的四点接触可将夹子卡在牙齿的最大径下方

Fig 3-4 Stable, four-point clamp contact beneath the maximum bulbosity.



图3-5 含有磨牙、前磨牙和蝶形橡皮障夹的标准盒

Fig 3-5 A standard kit containing molar, premolar and butterfly clamps.

（图 3-8a，b）来保证橡皮障的严密密封。

Incisor, "butterfly" clamps are available for anterior teeth, but it is often possible simply to secure the dam with a slip of rubber or a Wedjet® (Hygenic Corporation) (Fig 3-8a,b).

安装橡皮障

通常情况下，在橡皮障的中心部打一个孔即可（图 3-6a）。在橡皮障进入口腔前，将带翼的橡皮障夹安在橡皮障上（图 3-6b）。然后将牙齿小心地从孔洞中穿出，夹子滑向牙齿底部，自然地卡在颊面和舌面（图3-6c）。或者，也可以先上带翼或者不带翼的夹子，通过夹子牵拉出一个较大的孔来安装橡皮障。

Applying the dam

It is usually sufficient to punch a single hole somewhere near the centre of the sheet of rubber (Fig 3-6a). Winged clamps then allow the rubber to be attached to the clamp before it is carried to the mouth (Fig 3-6b). The tooth to be isolated is carefully visualised through the hole, and the clamp slid down in contact with the buccal and lingual surfaces to engage natural undercuts (Fig 3-6c). Alternatively, a winged or wingless clamp can be applied first, before stretching a rather larger hole over the clamp.

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图3-6 安装橡皮障。a. 在橡皮障的中心处打孔；b. 将橡皮障固定在橡皮夹上；c. 牙齿穿过孔洞，橡皮障夹喙部，滑向牙颈部；d. 取出夹翼，进行微调

Fig 3-6 Application of the dam. (a) A hole punched close to the centre of the dam. (b) Dam engaged on the wings. (c) Tooth to be isolated visualised through the hole and the jaws of the clamp slid to engage undercuts. (d) Close adaptation of the dam after disengagement of the wings.

然后将橡皮障从夹翼处分离开，并检查橡皮障的封闭性（图3-6d）。有些医师还采取一些其他措施调整橡皮障的接触点，使其接触达到最佳位置。

The dam should be detached from the wings of the clamp and checked for close adaptation around the tooth (Fig 3-6d). Some practitioners take the additional measure of flossing the rubber through contact points for better proximal adaptation.

尽管非常安全，橡皮障最大的问题仍是它的密闭性。无论有无液体进入的迹象，都应将Ultradent OraSeal®（图3-7a）或者Cavit等良好的橡皮障封闭剂用于牙齿的周围，以达到更好的

However it is secured, the critical issue is that the dam seals. If there is any sign of fluid entry, or even if there is not, a proprietary rubber dam caulking paste, such as Ultradent OraSeal® (Fig 3-7a) or Cavit

封闭效果。即使橡皮障不完全合适，OraSeal®也可以粘在潮湿的口腔黏膜表面，并泡沫化，填塞间隙（图3-7b）。这样，一个固定良好、封闭完全的橡皮障就可以快速可靠地安装好，使医师在进行精细操作和器械选择时无后顾之忧。橡皮障的安装过程并不困难和复杂。

对于易碎的牙齿或残冠，应使用裂隙型橡皮障。图3-8a展示了用裂隙型橡皮障隔离残冠的情况。先在橡皮障上为患牙两边的正常牙齿打孔，然后用剪刀剪成一条裂缝，橡皮障的收缩性可使其接触到患牙，如有必要，还可使用夹子、Wedjet®或者一小块橡皮条来满足其他要求。同样，可用OraSeal®来封闭任何缝隙。这样就不用担心次氯酸钠和涎液进入口腔。

should be piped around the tooth to provide a tight seal. OraSeal® sticks to moist mucosal surfaces and foams up to fill in gaps even when the dam is not very well adapted (Fig 3-7b). In this way a securely fixed, well-sealing dam can be placed quickly and reliably without getting bogged down in the finer details of technique and component selection. It does not have to be difficult or complicated.

For the fragile or decoronated tooth, a slit dam can be used. A slit dam isolation of a decoronated incisor is shown in Fig 3-8a. A hole was punched for the teeth either side of the damaged tooth. The holes were then joined with scissors to form a slit. The rubber self-retained after knifing through contact points. This can be supplemented with clamps, a Wedjet® or a small slip of rubber cut from the dam if needed. Ora-



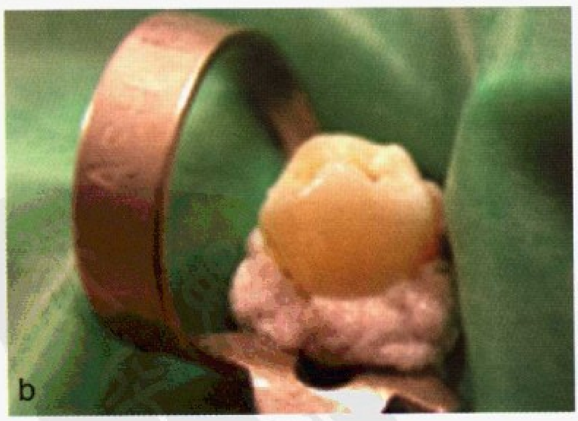


图3-7 橡皮障封闭剂 a. OraSeal®封闭剂；b. OraSeal®粘住口腔黏膜并泡沫化，提供良好封闭

Fig 3-7 Dam caulk. (a) OraSeal® dam caulk. (b) OraSeal® sticks and foams up to provide a tight seal.

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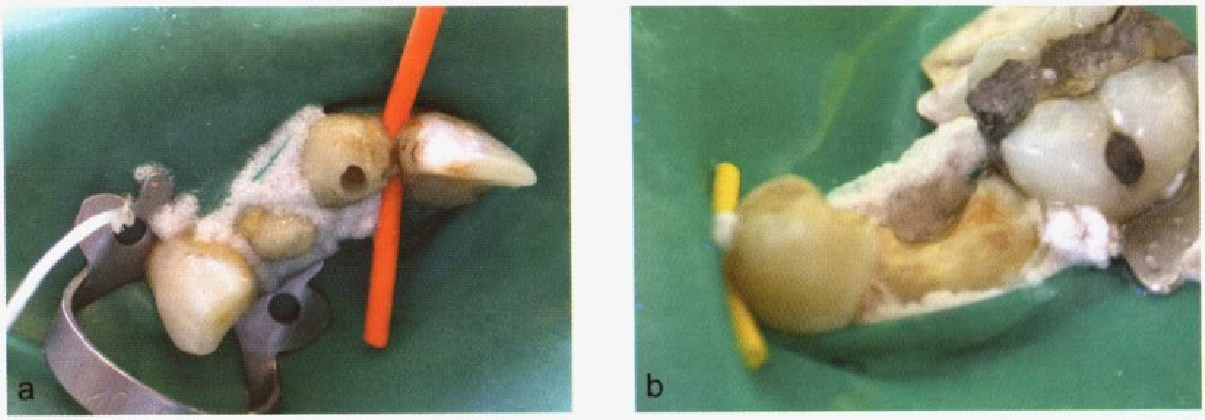


图 3-8　裂隙型橡皮障。在这个病例中，都使用了 Wedjet® 和 OraSeal® 来填塞缝隙。a. 易碎的前牙；b. 易碎的后牙

Fig 3-8 Slit dam applications. In both cases, the dam is secured anteriorly with a Wedjet®. OraSeal® plugs the gaps. (a) Fragile anterior teeth. (b) Fragile posterior tooth.

Seal® was applied liberally to seal any deficiencies. Sodium hypochlorite was employed as always without fear or complaint from the patient, and no saliva seepage was noted.

同样，对于受损的后牙也可采用此法，如图3-8b。在这个病例中，最后的磨牙被夹住，并用Wedjet®来对橡皮障进行缝隙填充，然后使用Oralseal®来进行隔离。这种简单的方法甚至在桥托中也可采用。

A similar scenario for a damaged posterior tooth is shown in Fig 3-8b. In this case, the distal molar was clamped and the rubber secured mesially with a Wedjet®. OraSeal® again completed the isolation. Even bridgework is no barrier to this simple approach.

医师不应讨厌使用橡皮障，橡皮障是牙髓治疗中的利器，如配合使用封闭剂，可用于大多数的病例。对没有使用橡皮障习惯的医师，最好购买一套橡皮障装置，并在模型上进行训练，以建立信心。

Dentists should not be put off by rubber dam. It is a jewel in endodontic practice, and can be applied in most cases with the help of a caulking agent. For those out of the habit of using rubber dam, it is wise to invest in a basic kit, and practise first on a model to build confidence.

除非进入路径受牙齿长轴方向的

Teeth should be isolated from the outset

限制，否则都应该用橡皮障来隔离牙齿。

unless there is concern about loss of long-axis orientation during access.

结　论

- 并非所有可以进行根管系统治疗的患牙均应该进行根管治疗。然而，一旦决定进行根管治疗，即使是止痛这样一个简单的步骤，也应在一开始就纳入全盘考虑的范畴。
- 在制订治疗计划时，应遵循控制感染这一根本原则。
- 牙髓治疗中必须用橡皮障来隔离患牙，其操作过程并不复杂耗时。

Conclusions

- Not all teeth that can be root treated should be. Even teeth treated with a simple endodontic procedure for pain relief should be properly appraised within a broader plan of care before definitive root canal treatment.
- Due consideration should be given to the fundamentals of infection control in planning and preparing for treatment.
- Sealing rubber dam isolation is mandatory for endodontic care. This does not need to be complicated or time consuming.

拓展阅读
Further Reading

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第4章 进入根管系统

Entering the Canal System

目 的

介绍建立冠部通路对于快速有效去除牙髓感染的重要性，为安全地开髓揭顶及修整通路进入恒牙根管系统提供临床指导。

Aim

To describe the importance of coronal access for effective and efficient management of endodontic infection, and provide clinical guidance for safely uncovering and refining access to the canals of permanent teeth.

要 点

通过学习本章，应当理解牙体解剖结构对于进入路径的重要性，仔细修整冠部通路的重要性，并熟悉冠部通路常规预备所需的一些器械。

Outcome

After studying this chapter, the reader should understand the relevance of dental anatomy in defining access outline, the value of investing time in carefully refining coronal access, and be more conversant with some helpful tools for accessing routine cases.

进入——成功治疗的基础

清除感染的牙髓是一个系列过程（图4-1）：其成功取决于冠部通路的建立、根管预备、根管充填、冠方封闭等步骤。各个步骤环环相扣，其中冠部进入是基础，其目的是：

Access—The Foundation of Success

Managing endodontic infection is a sequential process (Fig 4-1). The consecutive stages of coronal access, root canal preparation, canal obturation and coronal seal build on each other to win success. Coronal access lies at the foundation, and

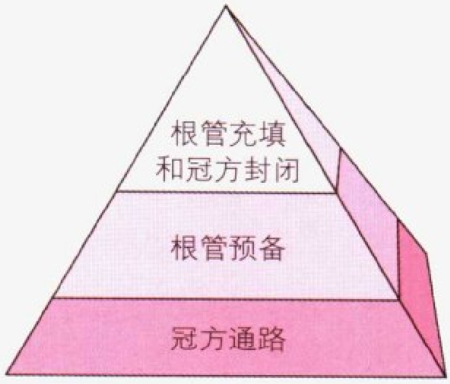


图 4-1 牙髓治疗步骤的金字塔结构。冠部通路是其他步骤的基础

Fig 4-1 The pyramid of endodon-tic treatment. Everything builds on coronal access.

- 完全揭开髓室顶，去除髓角和根管分支内所有感染和坏死分解的牙髓组织。
- 建立所有根管的冠部通路，清除软组织和感染物质。
- 建立简单的、器械不受力的直线进入通路，以便器械能安全、高效、易控地进入根管系统。
- 在满足上述条件的前提下，尽可能地保留牙冠组织。因为无论X线片上根管充填如何完善，过大的窝洞都会影响远期修复的效果，对患者毫无益处。

相比较而言，根管预备和根管充填的方法多种多样，而建立冠部通路作为根管治疗的一项准备工作，其过程沉闷乏味，有时还会出现精神上的紧张，于是常常被忽视。实际上，冠部通路预备事关根管治疗的成败，只有在进入下一步骤之前对其进行仔细地

aims to:

- fully unroof the chamber to clean infected and decomposing tissue from all of its pulp horns and ramifications
- uncover the coronal entrances of all root canals which need to be cleaned of soft tissue and infection
- allow simple, unstressed flight-paths for the safe, efficient and controlled use of instruments in the canal system
- preserve as much coronal tooth tissue as possible compatible with these aims. No matter how nice the final radiographic appearance of the root filling, a radical access cavity compromises long-term restorability and does our patients no favours.

Faced with exciting options for canal preparation and obturation, coronal access can be overlooked as a dreary – if sometimes stressful – precursor to be dispensed with quickly before the main event. In fact, coronal access holds the key to success and rewards those who check and refine their

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检查和修整，后面的操作才会成功。

如图 4-2 所示下颌磨牙的远中根充填完善，近中根管欠填。由于急于进行根管预备，未确认近中髓室顶是否完全揭开。在这种情况下，器械虽然可以毫无阻力地直线进入粗大的远中根管，但进入近中根管时，必须从远中弯曲着进入，这样就增加了操作的难度，容易失败（图 4-3a）。随着继续深入根管，器械需承受更大的、不必要的弯曲，在弹性回复力的作用下，锉开始伸直，楔入近中根管壁并形成台阶。预备

preparation before racing to the next stage.

A lower molar, well treated in the distal canal, but with a short and inadequate root filling mesially is shown in Fig 4-2. In haste to get on, the chamber was not inspected to identify and remove the mesial part of the roof. Instruments fell straight and stress-free into the wide distal canal but the flight path of instruments to the mesial was from the distal, more difficult and frustrating (Fig 4-3a). Advancing under great and unnecessary flexion, the files started to straighten,



图4-2 固定桥基牙的根充不完善，其预后无法预料，原因就在于没有建立器械进入的直线路径

Fig 4-2 A poor root filling and unpredictable bridge abutment, but where did the fatal problem arise?

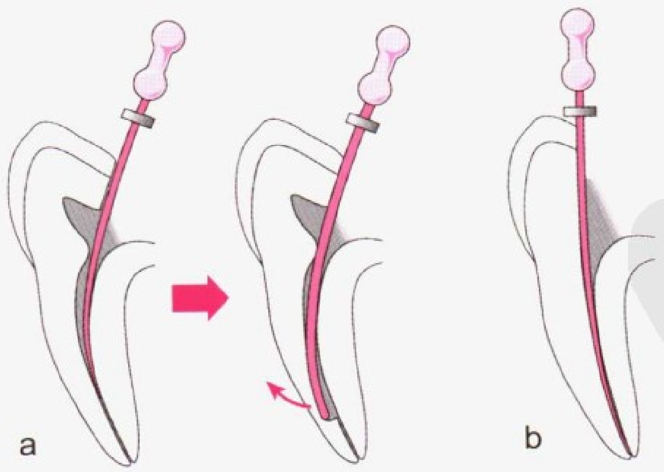


图4-3 a. 由于进入路径不畅，锉从远中进入时，很难找到近中的根管口。弹性回复力使锉在根管内形成无法越过的台阶。牙本质碎屑还有可能堵塞下方的根管；b. 良好的冠方通路可减少器械的受力和术者的操作压力

Fig 4-3 (a) Difficult flight-path from the distal to find the mesial canal orifices. Instrument recoil results in a ledge which may be impossible to bypass. Dentine mud may occlude the canal below, (b) The development of a proper flight-path reduces stress on the instrument and operator.

过程中每一次用力，台阶都会逐渐加深。这样只能够清理和充填根管的上半段，使得牙齿的愈后不良。

cutting into the mesial walls to create steps or ledges (Fig 4-3a) which deepened with every exasperated action. The canals were cleaned short, filled short, and the tooth now has a guarded prognosis.

揭开近中的髓室顶，为器械提供一个简便无压力的进入路径。使治疗得以成功，这需要多少时间呢（图 4-3b）？诚然，我们无法改变牙根的自然弯曲，但我们能够做到使器械处于无压力的直线状态。因此，良好的冠部通路是解决问题的关键，可以避免后续步骤中遇到的麻烦。

How long might it have taken to remove the mesial pulp chamber roof, provide a simpler, stress-free flight path and win the case with little or no frustration (Fig 4-3b)? We cannot do anything about natural root curvatures, but we can deliver instruments to them in a stress-free, straight line. Access holds the key if we are to avoid rolling problems into the following stages.

设计冠部通路——熟悉髓腔解剖结构及掌握开髓口的位置

Designing Coronal Access–Knowing the Anatomy and Where to Cut

正确揭除髓室顶须熟知牙髓所处的位置。

Rational unroofing demands that we know where the pulp is.

这可以从以下三方面进行推断：

- 权威教科书的经典图谱。
- 无失真的术前 X 线片。
- 对露髓点的肉眼观察。

Guidance is available from:

- classical illustrations in standard texts
- undistorted pre-operative radiographs
- direct visual inspection of the opened chamber.

理想化正常恒牙的髓腔解剖结构及开髓口的外形见图 4-4、图 4-6、图 4-8。实际上，许多情况下开髓位置与理想情况相去甚远，例如龋齿、拆除不良修复体后的牙齿以及可从露髓孔处进行开髓的牙齿。即便如此，熟知标准的开髓口形态也有助于指导开髓，进而获得良好的冠部通路。

Idealised pulp anatomy and outline forms for coronal access to sound or soundly restored permanent teeth are shown in Figs 4-4, 4-6 and 4-8. In reality, many teeth presenting for access are far from sound, with caries and defective restorations to be removed, and a large pulpal exposure as the initial entry point. Even here, classical outlines help to rationalise the direction of

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标准开髓口形态

上颌中切牙（图 4-4a）

平均长度：23.5mm

根管数目：1 个

开髓口基本形状：尖端朝向舌隆突的三角形。

冠髓形似鱼尾，近远中髓角在两侧向上突起。通常圆形的入口即可找到粗大的根管，但无法完全暴露髓角。当残留此处的感染牙髓组织发生分解时，可使牙齿变色。开髓过程中预备直线路径时，可向切缘扩展，但不应过多地向唇面扩展，以免影响美观。年龄增加可使髓腔形态发生变化——近远中向缩窄，并逐步向颈部退缩。所以老年人上颌中切牙的开髓口位置较低，近远中向的扩展也应较少。

上颌侧切牙（图 4-4b）

平均长度：22.5mm

根管数目：1 个

开髓口基本形状：尖端朝向舌隆突的三角形。

侧切牙在形态上像缩小版的中切牙，其牙根常常被误认为是直的。实际

cutting to develop good access from an unplanned initial opening.

Classic Cavity Outlines

Maxillary central incisors (Fig 4-4a)

Typical length: 23.5mm

Number of canals: 1

Basic access outline: triangular with apex at cingulum.

The coronal pulp is shaped like a fishtail, with mesial and distal pulp horns rising at the lateral limits. A circular access may find the often large canal, but will not properly unroof the pulp horns. Infection will be harboured, and the tooth may discolour as the retained tissue breaks down. For good straight-line access, the preparation will often graze into the incisal edge, but should not extend far labially to create an aesthetic compromise. With age, the pulp narrows mesiodistally and retreats cervically. Access in this case may commence lower on the crown, and be less flared mesiodistally.

Maxillary lateral incisors (Fig 4-4b)

Typical length: 22.5mm

Number of canals: 1

Basic access outline: triangular with apex at cingulum.

A smaller version of the central incisor, lateral incisors catch out the unwary who

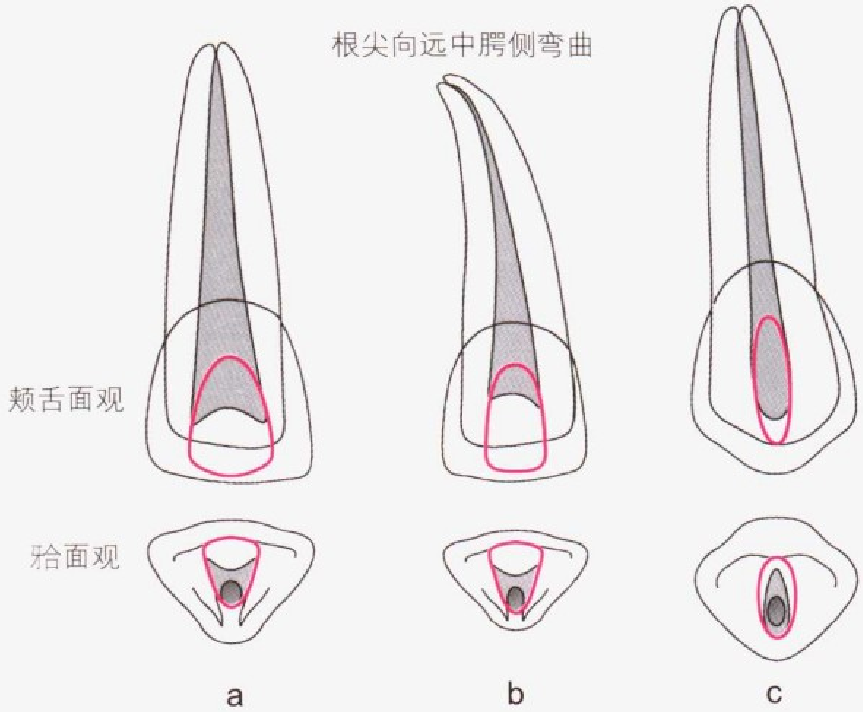


图 4-4　典型的恒牙牙髓解剖结构、根管位置、开髓口外形的颊舌面和殆面观。a. 上颌中切牙；b. 上颌侧切牙；c. 上颌尖牙

Fig 4-4 Buccolingual and occlusal views of permanent teeth showing classical pulp anatomy, canal position and access cavity outline. (a) Maxillary central incisor, (b) Maxillary lateral incisor, (c) Maxillary canine.

上，在距根尖2～3mm处，牙根明显地朝远中及腭侧弯曲，此处易形成台阶和侧穿（图4-5）。因此，初次预备根尖时需用弹性好的小号器械，并对其尖端的 2～3mm 处进行预弯（图 5-11）。

assume that the root is straight and fail to notice the marked disto-palatal curvature which is almost always present in the apical 2-3mm. Many are ledged or perforated at that point (Fig 4-5), and initial negotiation to the canal terminus often requires precurving the apical 2-3mm of small, flexible instruments (Fig 5-11).

上颌尖牙（图 4-4c）

平均长度：26.5mm

根管数目：1 个

开髓口基本形状：颊舌向的椭圆形。

Maxillary canines (Fig 4-4c)

Typical length: 26.5mm

Number of canals: 1

Basic access outline: oval buccolingually.

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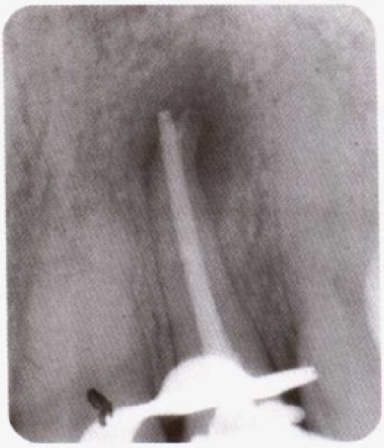


图4-5 这种情况多发于上颌侧切牙。绝大多数上颌侧切牙在根尖1/3处有明显的朝向远中及腭侧的弯曲

Fig 4-5 A common event in the maxillary lateral incisor. Most have a marked disto-palatal curvature in the apical third.

上颌尖牙只有一个髓角，且位于中央，因此开髓时无需近远中向扩展。当牙髓体积较大时，圆形的开髓口可能会导致近远中向过宽，却仍不能将髓角处的髓顶揭尽。随着年龄的增长，冠髓退缩至中心及颈部。开髓口位置应居中，形状接近圆形。

Maxillary canines have only one pulp horn, lying centrally, so there is no need to flare access mesiodistally. When the pulp is large, a circular access may be excessively wide mesiodistally, but fail to unroof the pulp horn. As the coronal pulp retreats centrally and cervically with age, the outline may be more central and circular.

上颌前磨牙（图4-6a, b）

平均长度：21mm

根管数目：第一前磨牙：多为2个；第二前磨牙：多为1个

开髓口基本形状：颊舌向的椭圆形。

上颌前磨牙髓腔近远中向狭窄，呈裂隙状，但颊舌向较宽。殆面中央的圆形开髓口并不能完全揭去髓角，并可能导致颊侧或舌侧根管的遗漏。

Maxillary premolars (Fig 4-6a, b)

Typical length: 21mm

Number of canals: first premolar – usually 2; second premolar – usually 1

Basic access outline: oval buccolingually.

Maxillary premolar pulps are narrow and fissure-like mesiodistally, but broad from the buccal to the lingual pulp horns. A mid-occlusal circular access will fail to unroof the pulp horns, and may cause a buccal or lingual canal to be missed.

上颌磨牙（图4-6c, d）

平均长度：21mm

Maxillary molars (Fig 4-6c, d)

Typical length: 21mm

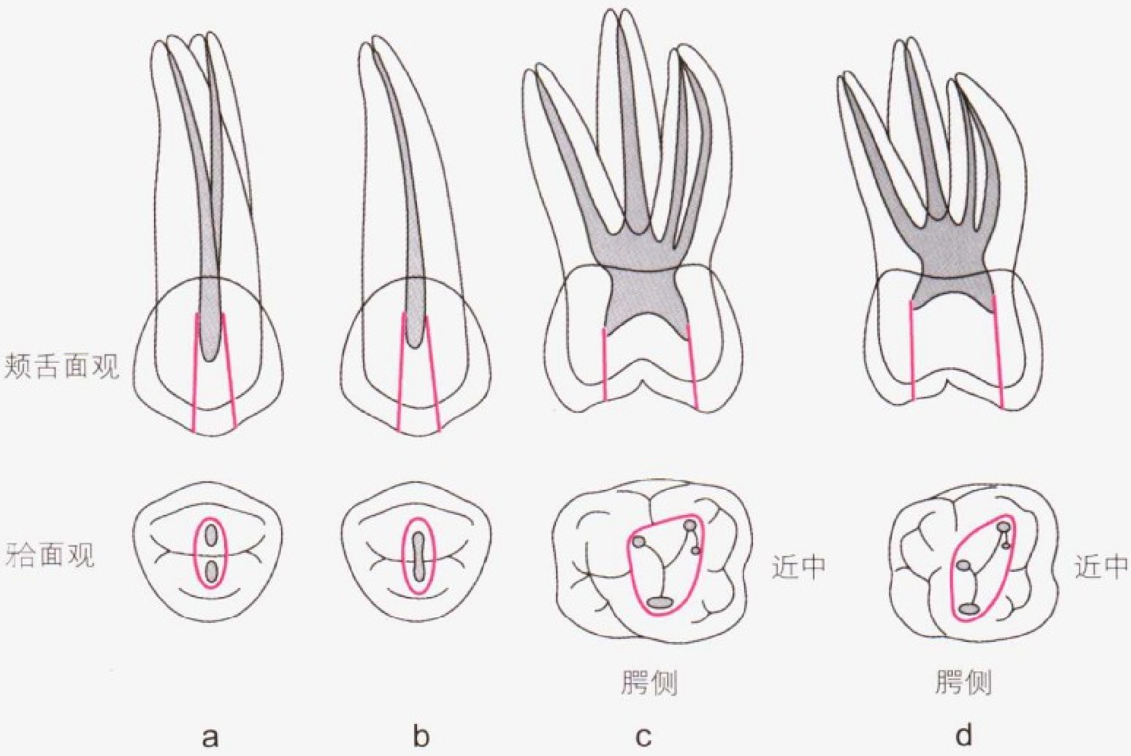


图 4-6　典型的恒牙牙髓解剖结构、根管位置、开髓口外形的颊舌面和殆面观。a. 上颌第一前磨牙；b. 上颌第二前磨牙；c. 上颌第一磨牙；d. 上颌第二磨牙

Fig 4-6　Buccolingual and occlusal views of permanent teeth showing classical pulp anatomy, canal position and access cavity outline.(a) Maxillary first premolar. (b) Maxillary second premolar. (c) Maxillary first molar. (d) Maxillary second molar.

根管数目：

近颊根：多为 2 个

远颊根：多为 1 个

腭根：多为 1 个

开髓口基本形状：三角形，位于斜嵴近中，尖端朝向腭侧。

进入上颌磨牙髓腔后的常见问题为：

• 没有对近颊主根管（近颊第一根管）的冠部通路进行正确的扩展和修整，器械不能够直线进入根管（参见本章随后对洞型修整的

Number of canals:

mesiobuccal root: usually 2

distobuccal root: usually 1

palatal root: usually 1

Basic access outline: triangular, placed mesial to the transverse oblique ridge, with the apex palatally.

The commonest issues in accessing maxillary molars are:

• failure to extend and refine properly for straight-line entry to the major mesiobuccal canal (see later in this chapter for cavity refinements), and

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讲述)。

• 没有找到发生率大于60%的近颊第二根管。

图4-7是离体的上颌第一恒磨牙牙根的横断面。可以看到,在横断面中,远颊根和腭根的形态大致呈圆形。由于牙本质呈同心圆排列,因此它们含有单个根管不足为奇。在颊舌向的X线片上,虽然近颊根与其他两根表现相似,但横断面上却完全不同。在横断面上,近颊根的颊腭向较宽,含两个根管甚至相互交织的网状根管。

近颊第二根管通常不容易找到,其根管口多位于近颊第一根管与腭根根管口连线的近中。可用DG16长探针探寻,但最常用的方法是用小号长柄车针或超声预备头在近中髓室底探寻来暴露根管口(图5-7,图5-9)。

• failure to locate a second mesiobuccal canal which is present in over 60% of cases.

The sectioned roots of an extracted maxillary first molar are shown in Fig 4-7. Notice that the distobuccal and palatal roots are generally circular in cross section. Knowing that dentine is laid down concentrically, it is no surprise that they contain one canal. Although similar looking on a buccolingual radiograph, the mesiobuccal root is quite different in section. It would be surprising if a root of such buccopalatal width did not contain two canals and even a web of tissue between them.

The second mesiobuccal canal is not always easy to locate, but it usually lies just mesial to a line joining the major mesiobuccal and palatal canal entrances. It may be possible to probe it with a long DG16 explorer, but it is usually necessary to run along the mesial chamber floor with a small long-shanked bur or ultrasonic tip (Figs 5-

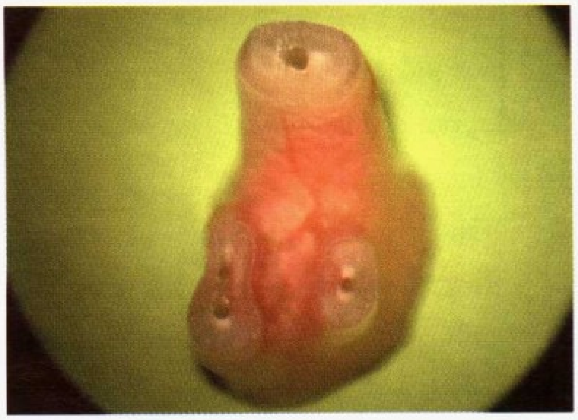


图4-7 上颌第一磨牙牙根的横断面 虽然在X线片上近颊根与远颊根相似,但近颊根的颊舌径远大于远颊根,且通常含有两个根管

Fig 4-7 Cross-section of maxillary first molar roots. Although the mesiobuccal and distobuccal roots can look similar on radiographs, the mesiobuccal is far wider buccopalatally and usually contains two canals.

7, 5-9) to uncover the entrance.

对腭根也需要引起注意，在术前的X线片上，腭根通常较直，但实际上腭根经常存在朝向颊侧的明显弯曲。

The palatal canal may also have surprises; usually appearing straight on the preoperative radiograph, it will often curve markedly towards the buccal.

与上颌第一磨牙相比上颌第二和第三磨牙的远颊根管口比第一磨牙更靠近牙体中央（图 4-6d）。

In maxillary second and third molars, the distobuccal orifice often lies closer to the centre of the tooth than in first molars (Fig 4-6d).

下颌切牙（图 4-8a）

平均长度：21mm

根管数目：多为1个，双根管率约为 30%

Mandibular incisors (Fig 4-8a)

Typical length: 21mm

Number of canals: 1; 2 in approximately 30%

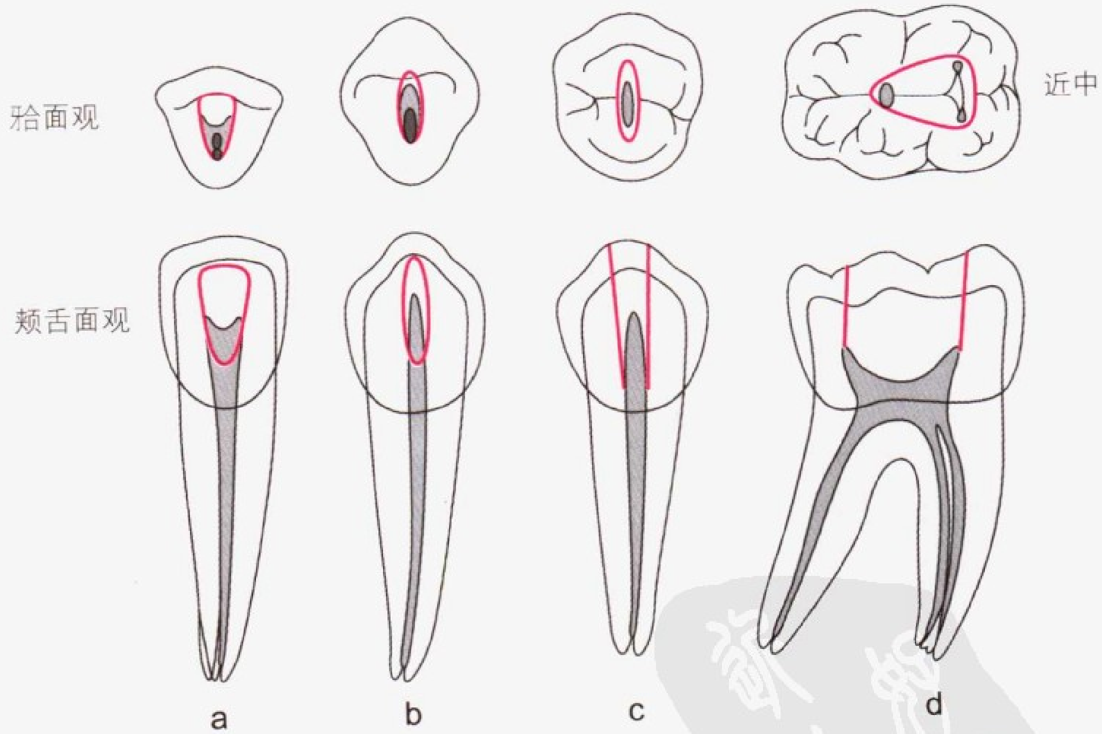


图 4-8 典型的恒牙牙髓解剖结构、根管位置、开髓口外形的颊舌面和殆面观。a. 下颌前牙；b. 下颌尖牙；c. 下颌前磨牙；d. 下颌磨牙

Fig 4-8 Buccolingual and occlusal views of permanent teeth showing classical pulp anatomy, canal position and access cavity outline.(a) Mandibular incisor, (b) Mandibular canine, (c) Mandibular premolar. (d) Mandibular molar.

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开髓口基本形状：尖端朝向舌隆突的窄三角形。

Basic access outline: a narrow triangle, with its apex at the cingulum

下颌切牙也是对进入通路要求较高的牙齿之一。其解剖形态复杂，边缘较窄且可允许的偏差更小。三角形的开髓口反映了近远中髓角的结构，向舌隆突作适当扩展有利于找到舌侧根管。为了能直线进入，切缘也可能被扩展到。

Lower incisors are some of the most challenging teeth to access, often with complex anatomy, and little margin for error. The triangular access reflects mesial and distal pulp horns, and extension into the cingulum is often needed to identify the lingual canal. The incisal edge is again just grazed for straight line access.

对于需要全冠保护的下颌切牙来说，可直接从切缘开髓，以保护舌侧壁和舌隆突，这对全冠的固位很有利。

In teeth where an extracoronal restoration is planned, there may be advantage in accessing more directly through the incisal to preserve the lingual wall and cingulum which will be important for crown retention.

下颌尖牙（图 4-8b）

平均长度：23.5mm

根管数目：多为1个，双根管率约为30%。

开髓口基本形状：颊舌向的椭圆形。

下颌尖牙冠部形态类似缩小的上颌尖牙，但通常有第二根管，开髓口向舌隆突扩展后可找到舌侧根管。

Mandibular canines (Fig 4-8b)

Typical length: 23.5mm

Number of canals: 1; 2 in approximately 30%.

Basic access outline: oval buccolingually.

A smaller version of the maxillary canine coronally, but often with a second, lingual root canal which is uncovered by extension into the cingulum.

下颌前磨牙（图 4-8c）

平均长度：21mm

根管数目：多为1个

开髓口基本形状：颊舌向的椭圆形

Mandibular premolars (Fig 4-8c)

Typical length 21mm

Number of canals: usually 1

Basic access outline: oval bucco lingually.

下颌前磨牙冠髓的近远中向比上颌前磨牙大，因此其椭圆形的开髓口在近远中向也稍宽。

The coronal pulp is often wider mesiodistally than that of maxillary premolars. Access is often a slightly wider oval to reflect this.

下颌磨牙（图 4-8d）

平均长度：21mm

根管数目：多为3个根管，近中多为2个，远中多为1个。

开髓口基本形状：呈三角形，尖端位于中线的远中。

下颌磨牙远中根管由髓室斜向远中，由于从近中直接进入远中根管相对较容易，因此窝洞的远中边缘超过殆面中央窝后，无需扩展太多。如果远中根管偏离中央，可能有双根管，此时窝洞的远中部分可向颊舌方向做适当扩展，形成长方形的开髓口。

最容易发生的错误是近中根管的直线路径不畅，使器械受力弯曲，形成台阶（图 4-2）。

应该注意到根管的三维弯曲情况。例如，约有40%的下颌磨牙其颊舌向的弯曲度大于近远中向，而这种弯曲X线片反映不出。

Mandibular molars (Fig 4-8d)

Typical length: 21mm

Number of canals 3: mesial usually 2; distal usually 1.

Basic access outline: triangular, with apex just distal to mid-line.

Note that the distal canal emerges into the chamber from the distal. Straight-line entry is simple from the mesial and requires no extension of the cavity much beyond the centre of the occlusal surface. If the distal canal seems off-centre, there is probably a second canal, and the cavity should be widened buccolingually to form a rectangular outline.

The commonest error is to provide a poor flight-path to the mesial canals, with resultant instrument flexion and ledging (Fig 4-2).

Third-dimension curvatures should always be anticipated. Almost 40% of lower molars, for example, will have canals with greater curvature in the unseen bucco-lingual plane than the mesiodistal plane.

X 线片

术前 X 线片应当如实反映牙齿大小，无失真，且处理过程良好。最重要

Radiographs

Preoperative radiographs should be life size, undistorted, well processed and, above

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的是应仔细分析X线片所反映的信息。从不同角度拍摄的X线片有助于建立牙齿及牙髓的三维结构影像（图4-9）。

高质量的术前X线片应能够提供以下信息：

- 髓室及髓室顶的深度及位置。
- 导致根管难以进入的形态结构改变（第五章有详细叙述）。
- 开髓深度和角度的定位（图4-10）。

在预备冠部通路时，尽管开髓后的窝洞相对较深但不宜选用长车针，用短车针足以到达髓室，车针过长有

all, inspected with care. It is often helpful to expose more than one film at different angles to build a three-dimensional picture of the tooth and the pulp system which formed it (Fig 4-9).

Quality preoperative radiographs provide information on:

- the depth and position of the chamber and its roof
- morphological changes which can make entry difficult (considered more fully in Chapter 5)
- orientation of depth and angulation (Fig 4-10).

Although coronal access is a relatively deep cavity, there is no merit in routinely choosing a long bur for the preparation.

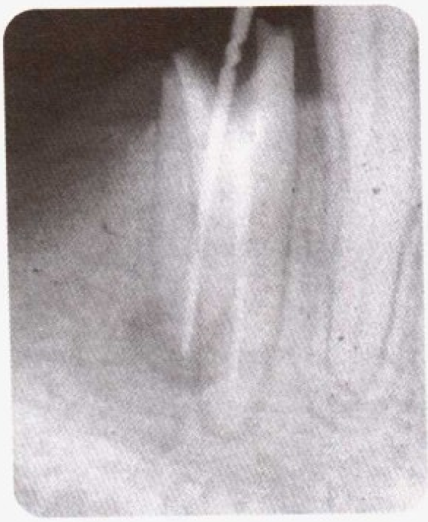


图4-9 颊舌向平行投射的X线片，两根管影像相互重叠，导致最初治疗时其中的一个根管遗漏 .

Fig 4-9 A straight buccolingual film during the initial treatment of this tooth left the second canal unidentified and untreated.

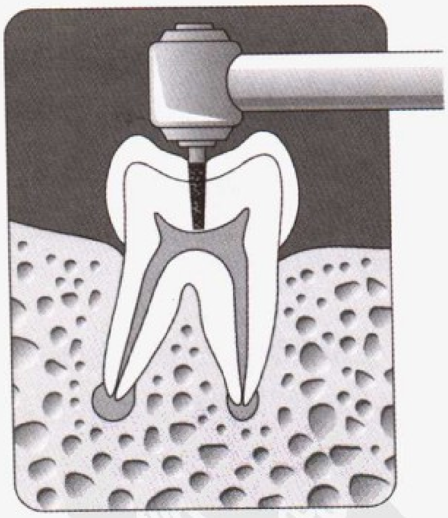


图4-10 无失真的术前X线片可判断开髓的常规方向和深度

Fig 4-10 Routine orientation of line and length from an undistorted pre-operative film.

可能会造成髓室底和根分叉的破坏。使用短车针的优点：

- 更容易控制垂直向的操作。
- 防止过度切割。

长车针可根据需要选用。

Why use a bur which can over-cut into a furca, when a shorter bur will reach the chamber and:

- be easier to accommodate with directional control in the vertical space available
- disallow further cutting before danger is reached?

Long-shanked burs should be reserved for cases in which they are needed.

操作步骤

开髓口形状及开髓方法

如果牙齿完整无损，应用中等锥度的金刚砂车针用高速手机在殆面预备标准的开髓口（图4-11a）。开髓预备洞型的过程中从髓角处进入，当到达预计的深度时，车针穿透髓室顶，此时会有突破感（图 4-11b）。多处的髓角穿孔可能会被误认为是根管口（图 4-12a）。髓室底不平坦，且非白色，其颜色暗淡，底部呈圆弧形，并有发育纹指向根管口（图 4-12b）。

Practical Stages

Outline and initial pulp access

If the tooth is sound or soundly restored, a classic outline is cut at high speed with a medium-tapered diamond bur (Fig 4-11a). As the cavity progresses, it is deepened in areas where the pulp is most prominent, and, at an anticipated depth, a satisfying drop may be felt as the bur falls through the roof (Fig 4-11b). Multiple punctures through the roof can be mistaken for canals (Fig 4-12a). Chamber floors are not flat and white, they are dark and domed with a map of lines guiding to canal entrances (Fig 4-12b).

此时，可以开始揭髓室顶，方法有两种：

- 用慢速球钻沿开髓孔朝外提拉（图 4-11c）。
- 以钝头车针（图4-13）进入髓室，沿髓室壁切割，暴露髓腔（图 4-11d，e）。

The chamber can now be fully unroofed, either with:

- slow-speed round burs, cutting on the outward stroke (Fig 4-1 lc), or
- safe-ended access burs (Fig 4-13), introduced to the pulp exposure, and directed around the chamber walls to

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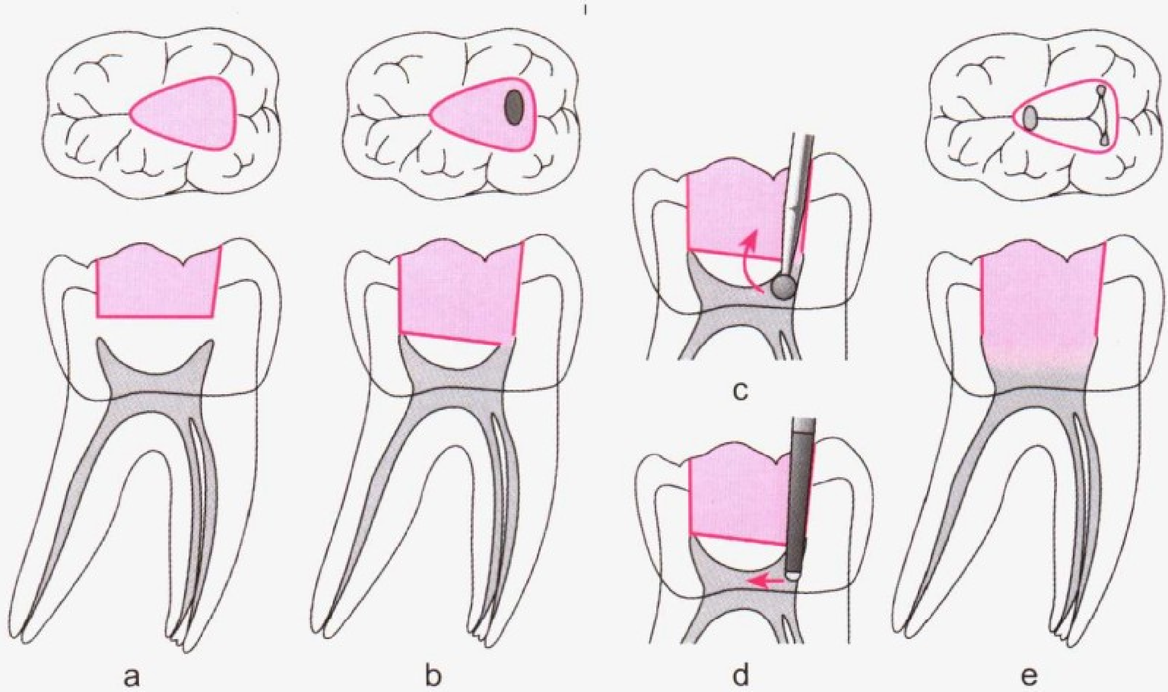


图 4-11 开髓步骤。a. 预备出正确的开髓孔外形，而不是仅仅是钻一个狭小的黑洞；b. 穿过髓室顶；c. 慢速球钻沿开髓孔向外提拉揭顶；d. 钝头车针沿髓室壁切割，切割效果明显又易于控制；e. 揭顶后的髓腔

Fig 4-11 Practical stages of access. (a) Outlining the correct form, not simply stabbing in through a narrow, dark hole. (b) Initial puncture of the chamber roof, (c) Removing the roof with a slow-speed round bur, cutting on the outward stroke, (d) A safe-ended bur, directed around the walls of the chamber. The results are impressive and predictable, (e) An unroofed chamber.

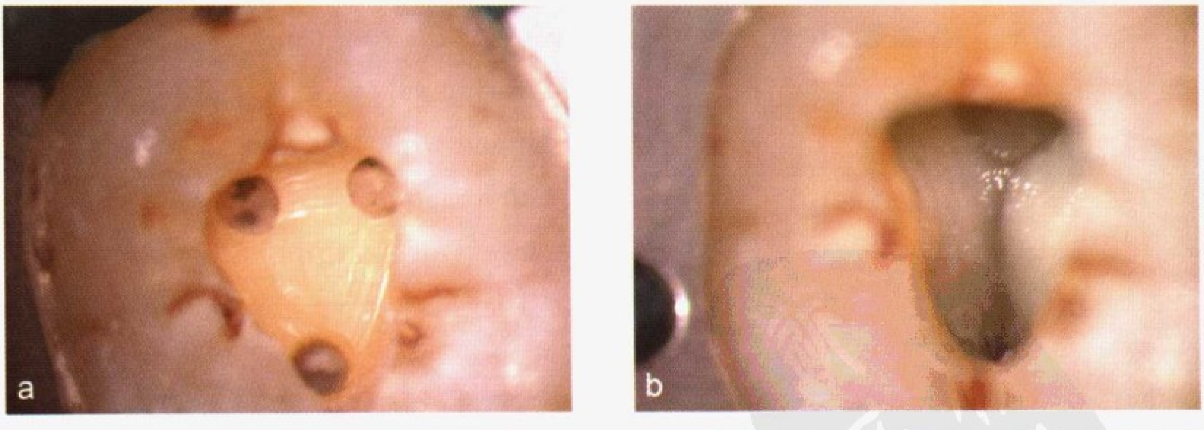


图 4-12 a. 多个露髓孔易被认为是根管口；b. 髓室底颜色暗淡，圆弧形，并有发育纹指向根管口

Fig 4-12 (a) Multiple punctures through the chamber roof. Are these canals? (b) The unmistakable dark, domed and fissured chamber floor with its road map leading to canal entrances.



图 4-13　钝头车针：高速碳钨车针 EndoZ® 和金刚砂车针 Diamendo®(Maillefer/ Dentsply)

Fig 4-13　Safe-ended access burs: highspeed tungsten carbide Endo Z® and diamond Diamendo® (Maillefer/Dentsply).

这两种方法可以保护髓室底的原有解剖结构，使操作易于进行。如果髓室底被破坏，变得平坦，或者预备时超出髓腔侧壁，原来利于操作的漏斗状根管口就会变成平面上的一个小孔（图 4-14），使器械进入根管需花费更多的时间。钝头车针可以有效地防止此类情况的发生。

reveal its contents (Fig 4-11d, e).

These methods preserve the anatomy of the chamber floor and make life easier. If the floor is flattened or preparation extends beyond the lateral limit of the chamber, a helpful funnel is converted to an irritating flat surface with a small orifice (Fig 4-14). The result is a frustrating and time-wasting preparation in which the operator spends more time getting instruments into canals than using them when they are in. Safe-ended burs will stop that happening and transform the practice of most users.

精　修

完全揭开髓室顶并不意味着已经提供了易于进入的直线通路。此时应当再花少量时间来考虑器械的进入途径，略作修整以利于器械进入。许多牙体牙髓学的专家在运用不可预弯的镍钛器械之前，一直在进行直线通路的修整。弹性良好的镍钛器械的使用使我们再一次认识到直线通路的重要意义。

Refinements

The chamber is now unroofed – but does it provide easy, straight-line access? A few moments should be spent considering the flight-paths of instruments, and making minor refinements for improvement. Many endodontists thought they made straight-line access until they started working with NiTi instruments which cannot be pre-curved. NiTi has forced a rethink of what

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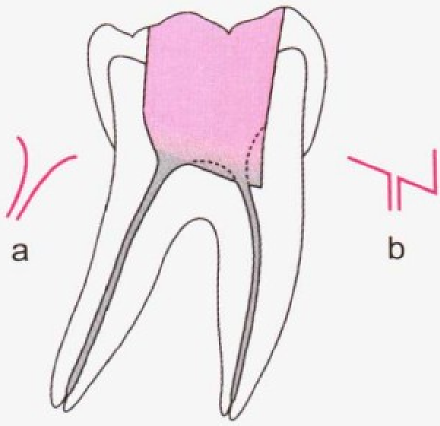


图4-14　保留根管口的漏斗状。a. 可以节省进入根管的时间，不要把根管口的形态变成平面上的小圆点；b. 根管口解剖结构的破坏将使器械进入根管花费更多的时间

Fig 4-14 Time and frustration are saved by preserving the funnel-shaped entrances to canals (a), rather than converting them to dots on flat surfaces (b). Damage to this anatomy results in more time expended getting instruments into canals than using them for preparation when inserted.

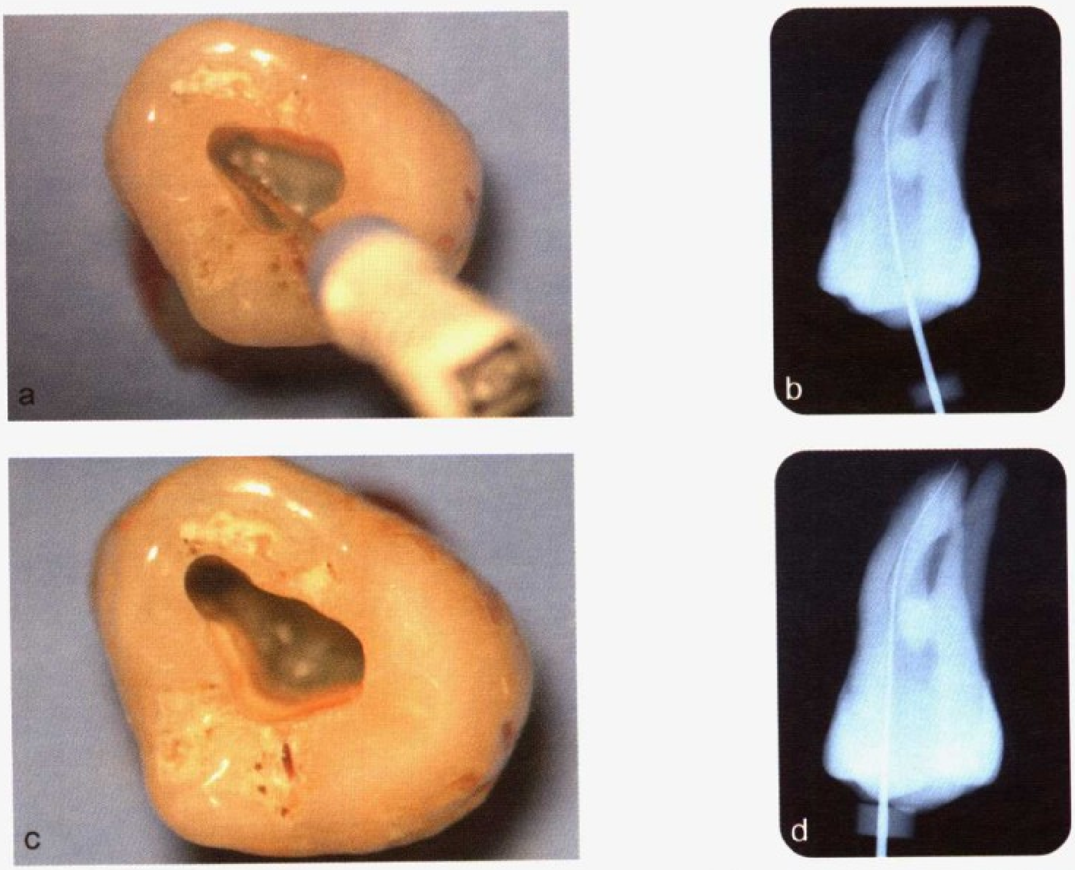


图4-15　a. 上颌磨牙的进入路径：这种路径是否能保证器械进入近颊根管时无阻力？b. X线片显示器械弯曲；c. 扩大根管口及去除阻挡的牙本质后，局部的髓腔壁变直，形成进入根管口的光滑通路；d. 锉进入时无压力，无需直视，器械就可以滑入根管口，节省操作时间

Fig 4-15 (a) Access to an upper molar, but is the path to the mesiobuccal stress-free? (b) Radiographic image, showing instrument flexion. (c) After countersinking the canal orifice, the wall was locally straightened to form a smooth chimney to the canal orifice. (d) File entry is now less stressed, and instruments can be slid down the chimney rather than having to visualise the canal entrance; a great time and frustration-saver.

图 4-15a 中上颌磨牙的冠部通路已经做了足够的预备，但近颊根管仍旧难以直线进入（图4-15b）。使用3号G钻，将根管口扩大，以利于用钝头车针去除颈部突出的牙本质，使根管进入路径变直（图 4-15c，d）。此处的预备可联合使用G钻或手用锉。这样，花数秒钟去除少量的牙体组织，就可以得到无压力的直线根管预备通路。图 4-16 显示的同样是为预备下颌磨牙的近中根管所做的洞型修整。

这种通路的建立，使我们无需直视根管口，就可以将器械准确沿平滑的侧壁插入已预备的光滑的根管中。

将髓室内注满次氯酸钠可以防止残髓出血，同时可以进行髓腔消毒和溶解牙髓。

we mean by straight-line access.

Adequate access to an upper molar is shown in Fig 4-15a, but entry to the mesiobuccal canal is hardly straight (Fig 4-15b). By countersinking the canal entrance with a Gates-Glidden drill size 3, space is made to accommodate the tip of a safe-ended access bur which can locally straighten the path to the canal entrance by removing a bulging overhang of cervical dentine (Fig 4-15c,d). The junction may need to be blended-in with a Gates or hand file. For the investment of a few seconds and a small amount of tooth tissue, access is now straight and stress-free. Similar, rational cavity refinements are shown for the mesial canals of a lower molar in Fig 4-16.

The canal orifice no longer needs to be seen; instruments will glide to length down the smooth chimneys which have been formed.

The chamber should be flooded with sodium hypochlorite to stem bleeding from pulp stumps and start the process of disin-



图 4-16　对下颌磨牙近中根管的修整

Fig 4-16　Similar refinements for the mesial canals of a lower molar.

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fection and pulp digestion.

常见错误

开髓定位错误和器械的不恰当使用常导致牙体预备过度。按照本章的指导原则，图4-17a中磨牙的开髓口及冠部通路的建立，在几分钟内就可完成，而且不会操作失误。但是，该磨牙近中侧壁和根分叉穿孔，导致牙冠的近中部分无法保留（图4-17b）。

同样，预备不足也可造成严重后果，会出现解剖结构的遗漏、感染难以处理和牙体变色等问题（图4-18）。

Common errors

Over-preparation usually results from loss of orientation and the use of inappropriate tools. Following the guidelines presented in this chapter, the molar shown in Fig 4-17a should have been accessed in minutes and with no fear of damage. Instead, it was perforated mesially and into the furca, and the mesial half of the tooth is now unrestorable (Fig 4-17b).

Under-preparation can be equally serious, with missed anatomy, intractable infection and discolouration amongst its consequences (Fig 4-18).

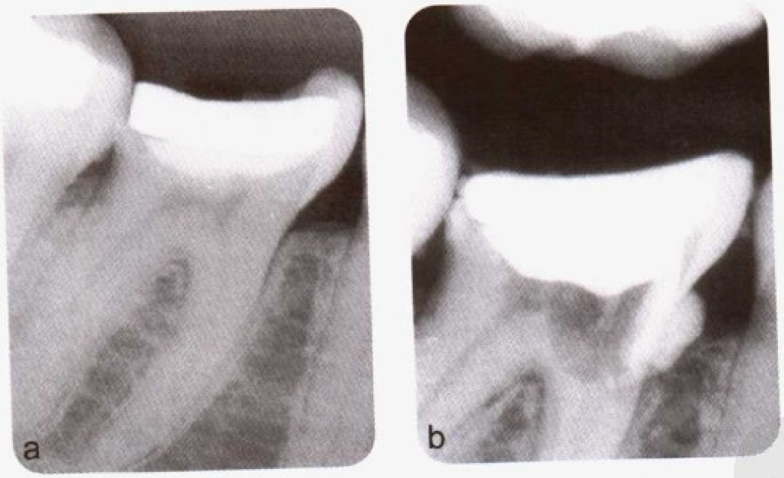


图4-17 a. 按照本章的指导原则，建立直线的进入通路非常简单；b. 正确地定位以及使用钝头车针可以避免这种情况的发生

Fig 4-17 (a) A simple molar to enter? (b) Correct orientation and the use of safe-ended burs should never have allowed this to happen.



图 4-18 冠部直线通路预备不充分，可导致解剖结构遗漏

Fig 4-18 Failure by missing the anatomy through an under-prepared access.

结　论

- 良好的冠部通路是根管治疗术成功的基础，可使后续工作事半功倍。
- 安全的操作包括对开髓深度和角度的定位，避免使用长车针，以及常规使用钝头车针揭顶。
- 直线通路的初步轮廓确定之后，应再次精修，建立使器械能简便、无压力的进入通路。
- 偶尔对离体的观察、横断面分析和进入的路径分析也十分有用。

Conclusions

- Access lies at the foundation of successful root canal treatment. Time and care taken at this stage rewards practitioners at all subsequent stages.
- Safe practice involves orientation of depth and angulation, avoidance of long burs unless necessary, and the routine application of safe-ended access burs to unroof the chamber without damage.
- When basic outline is complete, the cavity should be fine-tuned for simplified and stress-free entry.
- There is value in occasionally inspecting, sectioning and accessing extracted teeth on the benchtop.

拓展阅读
Further Reading

1 Burns RC, Herbranson EJ. Tooth morphology and cavity preparation. In: Cohen S, Burns RC (Eds.) Pathways of the Pulp. 8th ed. St Louis: Mosby, 2002:173–229

2 Walton RE. Access preparation and length determination. In: Walton RE, Tora-binejad M (Eds.) Principles and Practice of Endodontics. 3rd ed. Philadelphia: Saun-ders, 2002: 182–205

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第5章 进入“钙化”的根管系统

Entering “Calcified” Systems

目 的

描述使髓腔进入路径复杂化的增龄性变化，介绍有助于髓腔进入的各种方法。

Aim

To describe common age changes which complicate pulp access and introduce methods which may assist entry.

要 点

学习本章之后，应了解使老年人髓腔进入路径复杂化的各种生理改变，并掌握有助于根管定位和进入的各种技术。

Outcome

After studying this chapter, the reader should have greater understanding of changes which complicate entry to the aged tooth, and be conversant with a variety of techniques which may assist orientation and entry.

“钙化”髓腔治疗的困难

“钙化”根管系统的进入比较困难。大多数医师都知道治疗钙化牙齿的困难，这种情况常见于老年人大面积充填的牙齿中（图5-1）。此类牙齿易发生根尖周炎，常需转诊或拔除。

The Frustration of the “Calcified” Pulp

Entry to canal systems can be difficult. Most dentists know the frustration of the “calcified” tooth (Fig 5-1), a common finding in heavily restored teeth in ageing populations. Regrettably, such teeth are not immune to apical periodontitis. Compromise, referral or extraction are often the only solutions in practice.



图5-1　一名中年患者髓腔钙化导致的严重堵塞

Fig 5-1　Facing a brick wall! The calcified pulp system of a middle-aged patient.

牙髓空间变小的原因：

- 髓室和根管体积的减小。
- 髓室和根管内钙化物的沉积。

这些变化可以单独或联合出现。

Pulp space diminishes by:

- reduction of pulp chamber and canal volume
- calcified deposition within the chamber and canals.

These changes can present alone or in combination.

髓室和根管体积的减小

Reduced Chamber and Canal Volume

牙髓在一生中会持续形成牙本质，在磨牙主要位于髓室底和髓室顶，使原来宽大的髓腔变成浅碟形。这一过程使髓腔进入路径变得狭窄，且位置向牙齿中心移动。

Pulps continue to secrete dentine throughout life. In molars, this is mainly on the floor and roof of the chamber, converting it from a deep cavern to a flat disc (Fig 5-2a,b). This process also narrows the entrances and moves them closer to the centre of the tooth.

切牙和尖牙的髓腔会远离牙冠向中央方向移动（图 5-2c，d）。

Incisor and canine pulps retreat out of the crown and centrally (Fig 5-2c,d).

在龋坏、医源性刺激和磨耗过程中，髓腔内壁会出现不规则的刺激性牙本质形成，使髓腔的结构变得复杂（图 5-3）。

The picture in the crown can be complicated by irregular “irritation” dentine, secreted to wall off tubules exposed by caries, dentistry and wear (Fig 5-3).

根部牙本质的沉积呈同心圆状。

In roots, dentine deposition is always

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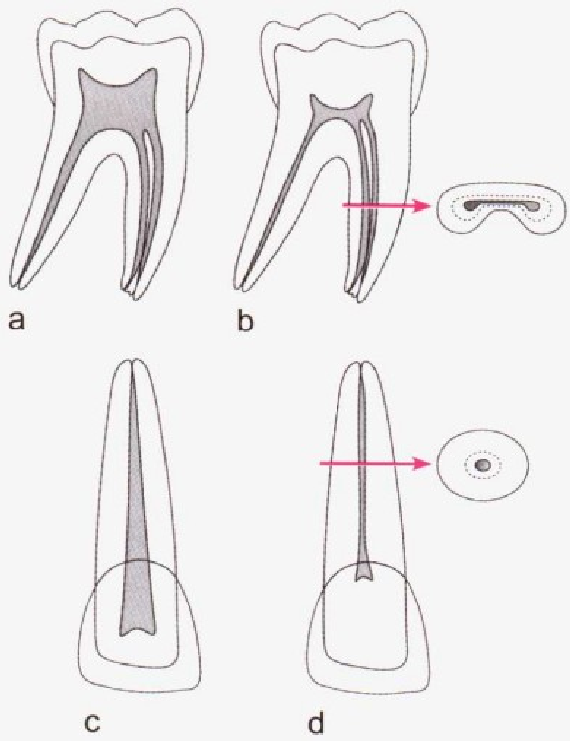


图 5-2 牙髓体积的增龄性变化。a. 年轻人的磨牙牙髓系统；b. 牙本质在髓室底和髓室顶沉积，形态变成浅碟形，如果车针使用不当，很容易引起穿孔，最容易穿孔的部位是根分叉处。根管也变窄，并向中心移动，同时根管的横断面呈现同心圆状狭窄；c. 年轻人的切牙牙髓系统；d. 冠髓向根尖及中心退化。根管横断面也出现同心圆状的狭窄

Fig 5-2 Age changes in pulp volume. (a) Molar pulp system in a young adult, (b) Dentine deposition on the chamber roof and floor converts it to a flat disc which is easily traversed without realising by a poorly orientated bur. The first "give" can be the furca! The canal entrances also narrow and move centrally, whilst in cross-section, the canals narrow concentrically, (c) Incisor pulp system of a young adult, (d) Retreat of the coronal pulp apically and centrally. In cross-section, the root canal again narrows concentrically.

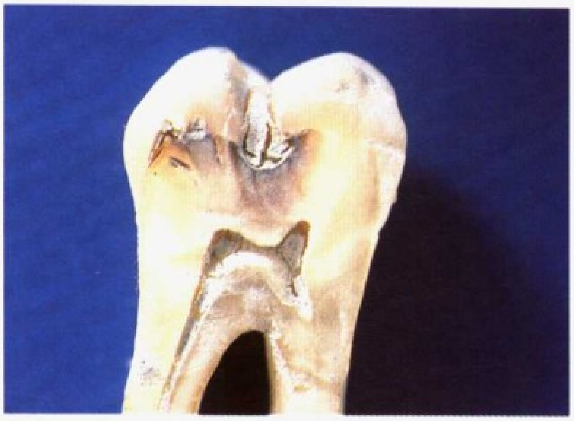


图5-3 不规则的刺激性牙本质在靠近龋坏的髓腔侧沉积

Fig 5-3 Irregular, irritation dentine laid down to wall-off tubules opened by canes.

在探查根管时候，根管位于沉积的牙本质团块的中央（图 5-2b，d）。

concentric. When searching and probing for the pulp in a root, it can only be in the centre of the mass of dentine which it formed (Fig 5-2b,d).

关于根尖钙化

根尖钙化通常会造成无法到达应有的工作长度。事实上，根尖不可能在形成过程中突然钙化。在这一保护性的根尖区域，其直径通常较上根管的直径更粗大。这是因为上方的根管由于经常受到外界刺激，牙本质沉积较多而相对较窄。根管深部的堵塞通常由于：

- 被压实的牙本质碎屑。
- 致密的牙髓组织。
- 根管过度弯曲，但在正常角度拍摄的根尖片上看不到。

根尖钙化也会出现假象，例如当有锥度器械进入平行或冠方狭窄的根管时，会出现阻挡（图5-4），这种阻挡常常出现于根管的冠部，导致器械被卡住，造成进入根尖困难，这种情况易被误认为是根尖堵塞。

What About Apical Calcification?

Failure to reach length in a canal is often blamed on apical calcification. In truth, canals do not suddenly calcify in their apical reaches, and are more commonly wider in this protected apical region than further coronally where external irritants can provoke dentine deposition. Deep obstructions usually represent:

- impacted debris
- compacted pulp tissue
- abrupt canal curvatures, often in a plane which is not visible in normal radiographic views.

The illusion of apical calcification can also arise as tapered instruments are advanced into canals with parallel or coronally narrowed walls (Fig 5-4). The interference actually lies coronally, causing the instrument to hang-up, making api-

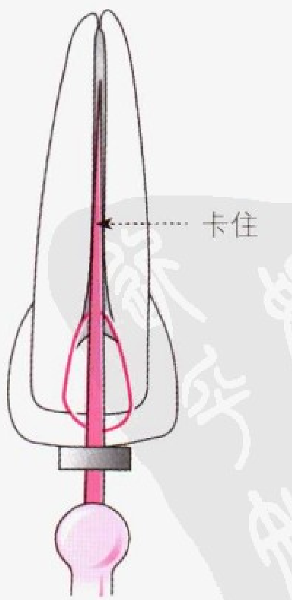


图5-4　锉卡住易被误认为是根尖阻塞。根管冠方的敞开可使锉进入更深

Fig 5-4　Hang-up of a file giving the illusion of apical obstruction. Opening the canal coronally allows the file to drop deeper.

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cal progress difficult, and rationalised in the mind of the operator as an apical blockage.

钙化物的成分

钙化岛位于牙髓内退变的血管和神经纤维周围，这些透明的沉积物并不是严格意义上的牙本质。它们在X线片上表现为致密的影像。在冠髓，通常为球形的“髓石”（图5-8），中间有散在的软组织，这些软组织可作为破坏和去除髓石的裂开面。还有一些髓石紧密地附着在沉积于髓室底或髓室壁处的继发性牙本质上。

髓石在根管内表现为线形钙化物，中间也有软组织散在分布，并具有湿牙签样的纹理，用锐利的探针可探查到。通常情况下，能够用探针探查到的只有龋坏、根管口和线形沉积物，因此这也是寻找根管口的好方法。

X线片上钙化内容物的致密影像掩饰了其中的软组织。这些软组织内容物一方面藏有可引起根尖牙周炎的微生物，另一方面也有助于我们进入根管系统。

老年人髓腔的复合变化如下图（图5-5）所示。

Calcified Inclusions

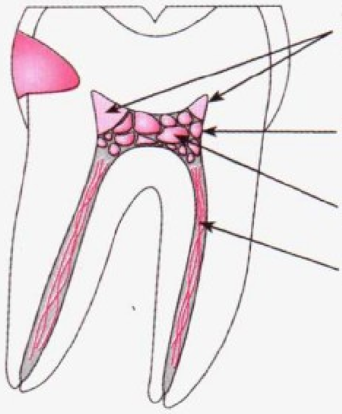
Islands of calcification form around degenerating blood vessels and nerve fibres in the pulp. These glassy translucent deposits are not strictly dentine, and can appear very dense on radiographs. In the coronal pulp, they are usually spheroidal "pulp stones" (Fig 5-8), interspersed with fronds of soft tissue which provide cleavage-planes for disruption and removal. Some may become firmly attached by incorporation into secondary dentine deposits on the chamber floor or walls.

Pulp stones are replaced in root canals by linear calcifications. Interspersed again with soft tissue, they have the texture of a wet cocktail stick and will cause a sharp probe to stick. Only caries, canal entrances and linear deposits will stick on probing — a helpful strategy in identifying and developing canals for entry.

The apparent density of calcified inclusions on radiographs belies their soft tissue component, which harbours the micro-organisms responsible for apical periodontitis, whilst greatly assisting entry.

The composite aged tooth is illustrated in Fig 5-5.

图 5-5 老年人髓腔系统的复合变化：引起牙髓体积变小，牙本质规则及不规则地沉积，髓腔和根管内充满髓石和线形钙化物
Fig 5-5 The composite aged tooth, with diminution of pulp volume by regular and irritation dentine deposition, and obliteration of this space with pulp stones coronally and linear deposits in the roots.



“钙化”髓腔的进入

进入“钙化”髓腔对视野和进入的方向要求很高：

- 光线明亮。
- 反光良好的口镜。
- 具有放大系统。

以上三者都是必不可少的辅助条件。最理想的条件是使用手术显微镜。即使是眼罩型的放大镜有时也能起一定作用。开髓的深度、方向和车针选择的介绍见第 4 章。

应经常检查进入的深度和方向，在牙髓完全暴露和开放之前，如果有小的出血点，可用电子根尖定位仪来确定其来源（图 5-6）。假如是髓室如为穿孔，应先用次氯酸钠和纸尖止血，然后立即用粘接材料或矿化三氧化物聚合体MTA（Maillefer/Dentsply）进行修复。

Entering the “Calcified” Chamber

Vision and orientation are critical:

- good light
- a front-silvered mirror
- magnification

are indispensable aids. In an ideal world, all would have the use of an operating microscope, but even the simplest of loupes will provide an edge. Guidelines for depth orientation and bur selection were presented in Chapter 4.

Depth and direction of cut should be constantly reviewed and small bleeding points checked with an electronic apex locator before they are assumed to be pulp exposures and opened widely (Fig 5-6). If a perforation is identified, bleeding should be controlled with sodium hypochlorite and paper points, before making an immediate repair with an adhesive material or Mineral Trioxide Aggregate (Maillefer/Dentsply).

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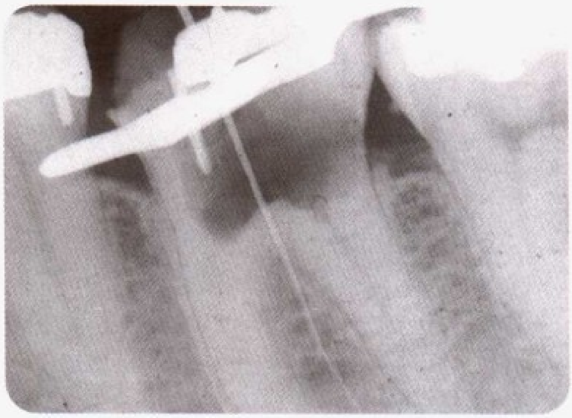


图 5-6 在完全打开前，仔细检查出血点。如果是穿孔，应立即干燥并封闭

Fig 5-6 Check the identity of bleeding spots before opening them widely. Perforations should be dried and sealed immediately.

在揭顶及扩大时使用钝头车针比较安全，但如果遇到髓腔狭窄或髓石较多的情况，揭顶的速度可能会受到影响。

Safe-ended access burs again allow safe removal of the chamber roof to its lateral limits, though progress may not be rapid if the chamber is shallow or filled with pulp stones.

去除髓石

通常可沿着髓石的裂开面将髓石破坏或者去除。用锐利的挖匙或探针，也可以去除髓石。超声刮治器对去除髓室底的髓石效果更佳，且不易破坏髓室底结构。如需使用车针，应使用缩颈车针，例如：

- goose-neck® (Meissinger)
- long-neck (LN)® bur (Maillefer/Dentsply)（图 5-7）

去除髓石的目的是为了能够看清颜色发暗的髓室底及其圆弧形结构，并找到发育纹，进而查明根管口。去除髓室里疏松的钙化物可避免其掉入根管而引起堵塞（图 5-8）。

Removing Pulp Stones

Pulp stones can usually be disrupted and removed along cleavage planes. A sharp spoon excavator or probe may be sufficient, but an ultrasonic scaler is especially useful and friendly to the chamber floor. If a bur is needed, it should be one with a narrow shank such as a:

- goose-neck® (Meissinger)
- long-neck (LN)® bur (Maillefer/Dentsply) (Fig 5-7).

The aim is to pick up the dark, domed floor of the chamber and find its fissured road-map which will lead to the canal orifices. It is wise to remove any loose calcified material from the chamber to avoid the risk and frustration of it falling into canals and blocking them (Fig 5-8).



图5-7　用来揭髓室顶和探寻根管的goose-neck或LN钻。其缩颈部保证在操作过程中，可以时刻观察工作头的工作情况

Fig 5-7 Goose-neck and long-neck (LN) pin burs for unroofing chambers and chasing canals. The narrow shaft allows the working head to be watched at all times.



图 5-8　磨牙揭顶过程中看到的发育纹

Fig 5-8 Work underway to unroof the road map in a molar.

进入含线性钙化物的根管

不要急于使用扩孔锉。除非根管的进入路径清晰，否则钙化根管会不断地使扩孔锉弯曲，造成锉的大量消耗。应首先使用较长的DG16根管探针探查可能的路径，用力插入根管，找出卡点。如探针无法探入，则扩孔锉也无法进入，此时应继续使用goose-neck或LN钻，并不断检查方向进行探查，直到出现了以下感觉：

- 根据经验，感觉此时应该停下来
- 感觉到有明显的卡点

Entering Canals With Linear Deposits

There should be no urgent hurry to pick up files. Unless there is a clear path for them to follow, they will repeatedly bend and quickly form an expensive pile of casualties. Possible entrances should be explored first with a long DG16 canal probe, inserted with firm pressure to detect a sticking point. If the probe does not stick, there is no path for a file to follow and excavation should continue with a goose-neck® or LN® bur, constantly checking orientation and probing. This process continues until:

- common sense suggests stopping or
- a convincing stick is felt.

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这时才可以换用小号锉进入根管。

Only then should small files be introduced.

也可使用细小的超声切割头去除阻挡的牙本质（图5-9），使用时需小心谨慎。如果没有根管显微系统，操作不易控制，很容易烧伤牙本质并使解剖标志变得模糊。

Careful dentine removal can also be achieved with fine, cutting tips attached to a piezoelectric ultrasonic unit (Fig 5-9). However, control can be difficult without magnification and it is easy to burn the dentine and obscure landmarks.

进　入

10号锉或小于10号锉进入根管时需使用润滑剂。应采用捻法：将锉放在示指和拇指之间来回搓动。使用时垂直方向的力量应该很小或是几乎不用力（图5-10）。应让锉顺着自身的路径进入。假如感觉到锉很紧，再搓动只会将其锁得更紧。这时应将锉取出，并将碎屑带出。通过搓动和除屑，锉继续深

Walking In

Files, size 10 or lower, should now be inserted with lubrication. The action of the file is a "watch wind": twiddling the instrument back and forth between forefinger and thumb pad with little or no vertical pressure (Fig 5-10). The file should walk its way into the canal. If progress is tight, twiddling will only lock the instrument tighter. The

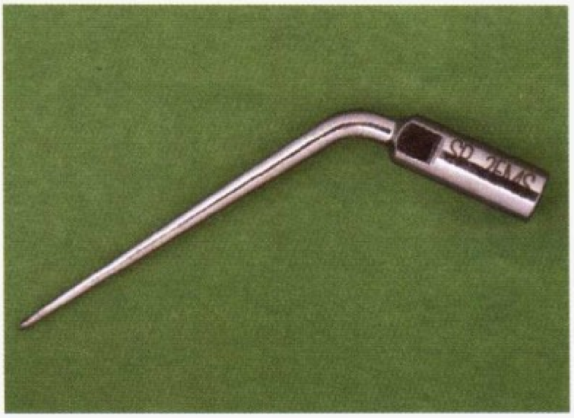


图5-9　超声切割尖

Fig 5-9　Cutting tip powered by ultrasound.

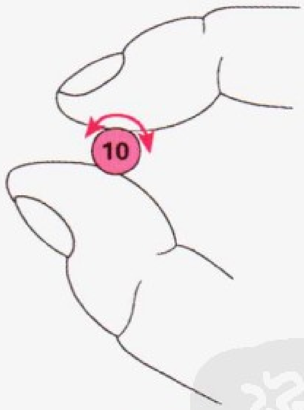


图5-10　使用小号锉采用"捻"法进入根管。假如感觉器械很紧，应将其轻轻退出，并使用润滑剂润滑根管

Fig 5-10　Watch-winding walks a small file into the canal. If the instrument feels tight, gently pull to remove dentine, free the instrument and allow the entry of more lubricant.

入，通过阻挡点后，会突然感觉到进入了宽阔的根尖区域，这时预备就会变得简单。

专用 EDTA 凝胶的作用是否仅限于使器械的进入变得容易和软化牙本质，目前还不明确。但使用这类物质，甚至是液体皂液，都会使器械更易进入。

阻力的大小

如果进入根管依旧很困难，应注意体会使用器械时的感觉。假如在取出锉时感觉到有轻微的粘附力，则根管内的阻力仍较大。但此时锉进入的方向往往没有偏差，可能仍在根管内，应继续使用捻法和除屑，直至到达根尖或是无法继续前进。

如果器械在根管内很宽松，却无法再进入，可能是由于存在X片上无法看到的三维结构上的弯曲。可把小号锉尖端的 2～3mm 平滑地预弯（图 5-11），并沿着根管的所有侧壁进行探查，努力找到粘附点。许多锉都带有可对根管弯曲方向进行定向和症状的橡皮片。应该记住，所找到的根管路径不一定位于预备的底部，而是经常位于侧壁上。

file should be pulled back to free it and “pick” debris away before proceeding. Twiddling and picking, the file will often reach a point where it suddenly drops into the wider apical portion of the canal and progress becomes simpler.

It is unclear whether the role of proprietary EDTA-containing gels is simply to ease the glide-path of instruments or to soften dentine. Whichever is true, instruments enter more easily with such agents or even with liquid medicated soap.

Tight or Loose Resistance?

If progress remains difficult, note should be made of how the instrument feels. If there is a slight sticking sensation as the file is withdrawn, this is tight resistance; the file is probably following the canal. Progress should continue, watch-winding and picking until the root terminus is reached or no further progress is possible.

If the instrument is loose in the canal but is making no further progress, the canal is probably curving, often in an unseen third dimension. The apical 2-3mm of a small file should be smoothly curved (Fig 5-11) and walked around all walls of the canal in an effort to find a stick spot which can be chased. Many files carry directional stops which assist file orientation deep in the canal. It should be remembered that the path which is sought does not necessarily lie at

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图5-11 将小号锉尖端的2~3mm进行预弯来适应根尖的弯曲。橡皮定向片有助于定向

Fig 5-11 Small file smoothly curved in its apical 2-3mm to negotiate an apical curve. Directional rubber stops can be helpful.

the depth of the preparation; it often exits on the lateral wall of the hole which has been created.

并不是所有的病例都能够达到理想的长度，但根管预备器械通常可进入大部分根管系统，从而有效地控制感染。

Not all cases will be won to ideal length, but patient and systematic instrumentation will allow entry to most systems for effective infection control.

根管非钙化型堵塞

Obstructing Non-calcified Canals

即使是最简单的根管在进入时也有可能堵塞。致密的牙髓组织像钙化物一样，也可以造成根管阻塞，最好使用拔髓针去除大部分牙髓组织。

Even the most simple of canals can be blocked during entry. Compacted pulp tissue can form as impassable a barrier as any calcification and is best avoided by gross pulp removal with barbed broaches.

在所有根管的预备中均应使用肥皂液或专用的EDTA凝胶之类的润滑剂，这将帮助器械穿过组织块，而不会将其压得更紧。

In all cases, canal negotiation should be accompanied by lubrication with soap or a proprietary EDTA paste to help instruments glide into masses of tissue rather than simply compact them.

预备过程中牙本质碎屑引起的阻塞，可以通过频繁而深入的冲洗，以及不断地用小号锉（10号或者更小）插入根管至根尖孔或穿出根尖孔1mm，来保持根管的通畅和可控。

Subsequent blockages with dentine mud should be avoided by frequent, deep irrigation and occasional passage of a small (size 10 or lower) file through the full length of the canal, extending passively 1mm or

还应经常使用次氯酸钠对髓室进行冲洗，为随后的根管清洁和预备成形做准备。

so through the apical foramen to keep the entire canal patent and under control.

The chamber should always be flooded brim-full with sodium hypochlorite solution in preparation for formal cleaning and shaping.

结　论

- 钙化的根管系统日益多见，阻碍了常规方法的使用。
- 增龄性变化包括：髓腔体积减小和钙化物的阻塞。
- 根管系统很少完全钙化。
- 在使用超声仪器、长车针和根管探针时，充足的光线、显微放大系统和耐心是治疗过程中所必不可少的。在没有找到根管进入路径之前，不应使用锉。
- 致密的牙髓组织可如同钙化物一样，也可造成根管阻塞。

Conclusions

- Calcified canal systems are increasingly common and can thwart conventional approaches to access.
- Age changes include both diminution of pulp volume and obliteration with calcified inclusions.
- Canal systems are rarely completely calcified.
- Light, magnification and patience are indispensable aids during the careful use of ultrasound, long burs and canal probes. Files should not be picked up until there is a path for them to follow.
- Compacted pulp tissue can provide as impassable an obstruction as calcified material.

拓展阅读
Further Reading

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第 *6* 章 为根尖周的健康创造条件

Creating the Conditions for Periapical Health

目 的

从控制感染和为根尖周创造健康环境的角度出发，全面地了解根管预备的基本原则。介绍各种手用和机械器械预备根管的方法，以便有效地清洁和封闭根管。

Aims

To provide a comprehensive overview of the fundamental principles of root canal preparation in terms of infection control and creating an environment compatible with periapical health. To describe a variety of manual and mechanised methods of shaping canals for effective cleaning and sealing.

要 点

学习本章节之后，应掌握以下内容：机械扩大、冲洗和药物在消毒清洁根管系统中的作用；传统的根管预备工具和使用方法的缺点；目前根管锉的设计、金相结构及使用要点。

Outcome

After studying this chapter, the reader should understand: the role of mechanical enlargement, irrigation and medication in cleaning root canal systems; the shortcomings of traditional enlarging tools and action; and the advantages of contemporary file design, metallurgy and motion.

预备的原则

根管预备是控制感染的关键步骤。它通过以下途径来保护根尖周的健康：

• 清洁根管，去除微生物，细菌毒

Principles of Preparation

Canal preparation is the key infection-controlling step. It secures periapical health by:

• cleaning the canal system to remove

素及其底物。

- 塑造良好的根管内部形态，以便封闭根管生长，阻止细菌侵入、汲取营养和繁殖。

根管清洁和成形可通过器械、冲洗液和局部药物消毒的共同作用而完成，侧重点因实际情况不同而异。例如，粗大的、有一定锥度且无根尖牙周炎的根管，所需的机械预备和消毒，要比有根尖周炎的细小根管要少。

microorganisms, microbial toxin and substrate

- shaping to create an internal form which can be sealed throughout its length against microbial entry, nutrition and multiplication.

Cleaning and shaping occur simultaneously by the synergistic action of instruments, irrigants and local medicaments, the emphasis of which will vary according to the case. A wide, tapered canal in a tooth without apical periodontitis may, for example, require less mechanical shaping and disinfection than a fine canal in a tooth with apical periodontitis.

根管扩大器械、冲洗液和局部药物的作用

用器械扩大根管的主要目的是通过切割牙本质，来达到以下目的：

- 机械性清洁
- 方便根管冲洗
- 获得严密根管充填所需的良好形态

机械预备的最佳结果是所有主根管的同心圆性扩大（图 6-1a）。理想的预备系统应该达到以下标准：

- 安全
- 可控
- 可以根据根管清洁的需求来预备，不要局限于经验标准或者器械的使用限度。

The Role of Enlarging Tools, Irrigants and Local Medicaments

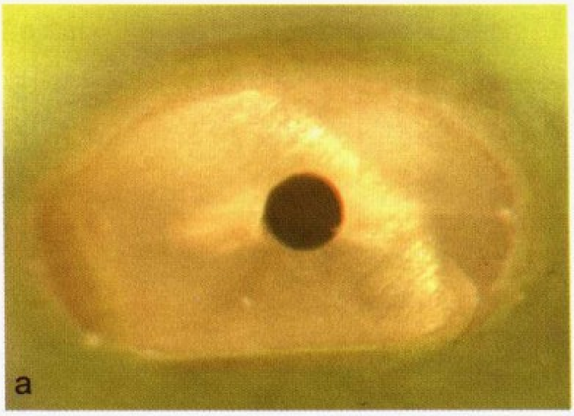
Instruments enlarge canals by cutting dentine and provide:

- mechanical cleaning
- access for irrigation
- adequate shape for compaction of the root filling.

The best outcome from mechanical instrumentation is concentric enlargement of all major canals (Fig 6-la). An ideal system would achieve this:

- safely
- predictably
- according to the cleaning needs of the canal,not to an empirical norm or a point dictated by instrument limitations.

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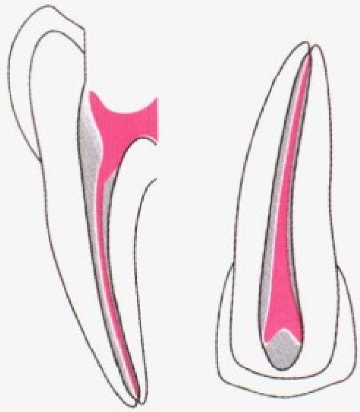


图 6-1 a. 同心圆性根管扩大；b. 从纵剖面来看，预备后的根管应位于原有根管的中心，并具有从冠方向根方的平滑锥度

Fig 6-l (a) Concentrically enlarged root canal, (b) Longitudinally, preparations should be centred on the original canal and form smooth, regular tapers, from apical to coronal.

从纵剖面来看，预备后的根管应具有平滑的特点，最窄处位于根尖，最宽处位于根管口。这是目前有效充填根管的最佳形态（图 6-1b）。

Viewed longitudinally, it would always produce a smoothly tapering preparation with its narrowest point apically and its widest point coronally–currently the optimal shape for effective sealing (Fig 6-lb).

冲洗液可通过润滑器械的进入路径和冲洗碎屑，来达到辅助根管扩大的目的，否则易导致根管阻塞及清洁不彻底。严格来说，冲洗液还可以清洁器械难以到达的网状根管、根分歧、交通支和副根管等结构。因此，冲洗液应具有抗菌和溶解牙髓的作用：

Irrigants support enlargement by lubricating the path of instruments and flushing cutting debris, which may otherwise cause blockages and compromise cleaning. Critically, they also clean the complex webs, fins, anastomoses and accessory canals which instruments will never be guided to enter (Fig 6-2). As such, they should have antimicrobial, and pulp-dissolving activity.

- 次氯酸钠溶液仍然是标准的冲洗液，通常家用的漂白剂（注意保护患者的眼睛和衣物），用等量的水稀释后，即成浓度约为 2% 的次氯酸钠冲洗液。

- Sodium hypochlorite solution remains the gold standard, usually thin household bleach (always protect the patient's eyes and clothes), diluted with an equal volume of water to give an approximately 2% solution.

浓度稍高或稍低仍可使用，但其

Greater or lesser dilution is also accep-

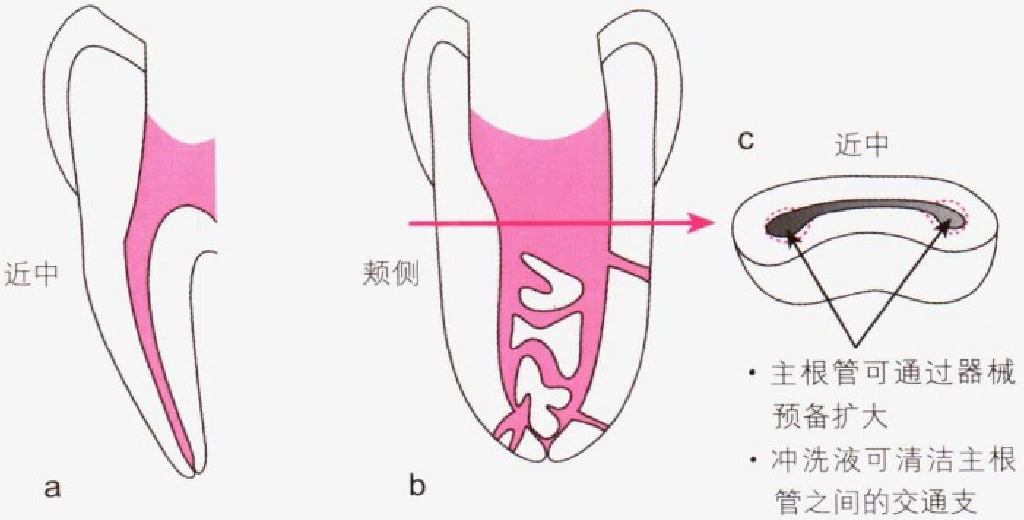


图 6-2　a. 临床上所见的下颌磨牙根管颊舌向的典型形态；b. 实际上，从近远中方向观察上颌磨牙近中根，可见其颊舌侧均膨大形成根管，并且在每一水平面也有广泛的交通支；c. 根管间网状交通支的横断面。器械预备可以扩大主根管，冲洗液可以对根管分支进行清洁和消毒

Fig 6-2　(a) Typical mind's-eye view of a lower molar root canal in clinical, bucco-lingual view, (b) Closer to reality. Mesiodistal view of a lower molar mesial root, with areas of expansion "canals" buccally and lingually, curving in three dimensions, and with complex branching and interconnection at every level, (c) Cross-sectional view illustrating the web of communication between "canals". Enlarging instruments will shape the main canal areas, leaving the ramifications to be cleaned and disinfected with bleach.

清洁能力随下列因素的增加而增加：

- 浓度
- 体积
- 温度
- 振荡

• 也可以使用 0.2%的洗必泰，它有较强的抗微生物作用，但无组织溶解能力。

• EDTA 液体或凝胶交替使用可用来去除玷污层和开放牙本质小管，有利于根管消毒，但这个优

table, though its cleaning activity increases with:

- concentration
- volume
- temperature
- agitation.

• Chlorhexidine gluconate (0.2%) is an acceptable alternative, with substantive antimicrobial action but no tissue-dissolving capacity.

• EDTA fluid or gel can be alternated to remove smear layer and open dentinal tubules for disinfection, though the

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点目前还有争议。

• 局麻药物作为应用最广泛的冲洗液，不过其既无抗菌作用也无组织溶解能力，且成本较高。

冲洗使用细的钝头冲洗针头（图6-3）有以下优点：

• 可深入冲洗。
• 较大的有效冲洗剂量。
• 冲洗压力低。

针头与Luer-Lor型注射器之间应安全连接。用手指压住活塞来控制压力，防止冲洗液超出根尖孔。还可以安装橡皮阻挡片或者将针头弯曲等辅助措施，来限制进入的深度，防止起出。

频繁的冲洗可以保持冲洗液的化学活性，有助于牙本质碎屑的排出。超声波可加热和振荡根管中的冲洗液，使其清洗根管壁及根管分支的效果更

merits of this action remain contentious.

• Local anaesthetic, the most popular irrigant, has neither antimicrobial nor tissue solvent activity and is an expensive agent to flush cutting debris.

Delivery is with narrow, safe-ended irrigating needles (Fig 6-3) which facilitate:

• deep
• high volume
• low pressure exchange.

They should be securely attached to a labelled Luer-Loc syringe. The plunger is depressed with a finger to limit pressure which could force solution beyond the apex. An added precaution is to fit a rubber stop or to bend the fine needle to allow depth orientation and prevent over-extension.

Frequent flushing refreshes the chemical activity of the irrigant and helps dislodge loose debris. The application of ultrasound to a flooded canal goes further by

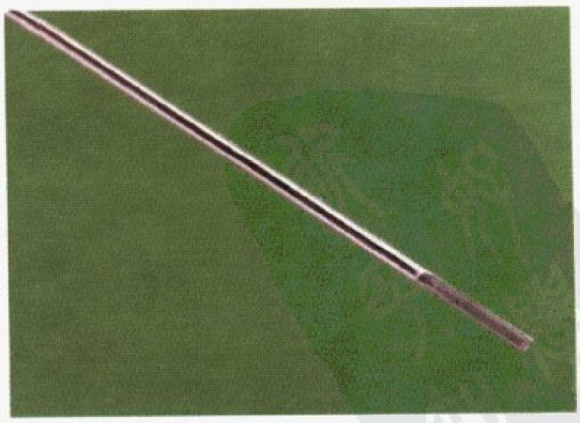


图6-3 钝头的Monoject冲洗针尖端被切掉，可防止压力过大冲出根尖孔。与其相连的应力Luer-Loc注射器，而非普通的注射器。深部冲洗时，可将其末端平滑地弯曲

Fig 6-3 Safe-ended Monoject endodontic irrigating needle incorporating a cut-out area which guards against dangerous build-up of pressure and apical extrusion of canal contents. They should always be attached to a labelled Luer-Loc, not friction-grip syringe, and can be smoothly bent for depth orientation.

好。超声活化次氯酸钠冲洗液可能是目前牙髓病治疗中最有效的冲洗方法。

warming the solution and creating violent turbulence to scrub canal walls and ramifications. Ultrasonically activated sodium hypochlorite is probably the most effective cleaning regime in endodontics.

局部药物的应用可作为器械预备和冲洗的有效补充，可使根管内部保持长期清洁。传统的挥发性药物，例如类单氯苯酚，通过挥发来消毒根管系统，但具有刺激性，且在数小时内会失去抗菌活性（气味仍然存在）。其他的药物有：

Local medicaments supplement instruments and irrigants and offer longerterm inter-appointment cleansing. Traditional volatile agents such as paramonochlorophenol, whose vapours allegedly fumigate canal systems, are irritant and lose their antimicrobial effectiveness (but not their smell) within hours. Worthwhile alternatives include:

- 非固化型氢氧化钙，它有以下特点：
  - pH 值较高。
  - 持续、广谱的抗菌活性。
  - 有助于溶解坏死的牙髓组织。
- 洗必泰凝胶（2%），具有持续广谱的抗菌活性（包括粪肠球菌）。

- non-setting calcium hydroxide, with its
  - high pH,
  - lasting, broad-spectrum antimicrobial activity and
  - ability to assist in dissolving necrotic pulp tissue.
- chlorhexidine gel (2%), with its lasting broad-spectrum antimicrobial action (including activity against *E. faecalis*).

不推荐使用抗生素。当消毒剂可以同样发挥作用或者效果更好时，应该避免使用抗生素，另外消毒剂也没有耐药性。

Antibiotic drugs cannot be recommended and should be avoided when a disinfectant will do a similar or better job without the risk of selecting micro-bial resistance.

传统的预备方法

The Trials of Traditional Preparation

用传统方法对根管进行扩大时，

Canals have traditionally been enlarged

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采用的是锥度较小的不锈钢器械（图6-4）。确定工作长度后，在根管冠方开放之前，凭经验来预备根尖区。器械的设计和操作方法使得根管预备复杂耗时，操作失误的概率增高，且容易出现根管的阻塞及器械的偏移。

阻塞的原因：

- 锉的上下运动会产生并压紧碎屑。
- 根向冠方向的预备，不如由冠向下预备那样可以容易去除碎屑。
- 在根管预备过程中，没有经常检查根管的畅通性。

结果均可导致根管清洁和充填不彻底。

with modestly tapered stainless steel instruments (Fig 6-4). After determining length, the apex was empirically enlarged, before stepping back to create flare for filling. Instrument design and motion made for complex, time-consuming preparation, with limitless opportunity for error. Blockage and deviation of instruments from a centred position (transportation) were the norm.

Blockage resulted from:

- up-down filing motions which dislodged and packed debris
- preparation from apex to crown, instead of clearing debris as the case advanced in a crown-down sequence
- failure to check the free-running patency of the canal at frequent intervals during treatment.

The outcome was incompletely cleaned and filled canals.

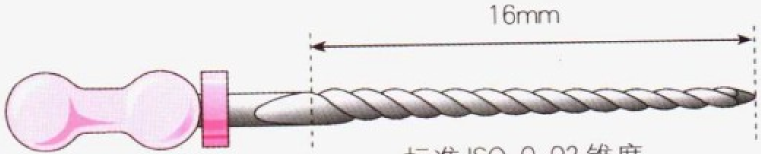


图6-4 ISO标准根管锉含有长度为16mm的切割刃以及0.02mm的标准小锥度。其长度每增加1mm，宽度增加0.02mm。这个标准的制定受限于上世纪中期器械的加工工艺，没有考虑根管的清洁和成形的需要

Fig 6-4 An ISO standardised endodontic file with 16mm of cutting blades and a standard, modest taper of 0.02mm mm^{-1}. For every mm of the bladed area, the instrument becomes 0.02mm wider. This standard was probably based on limitations of instrument manufacture in the middle of the last century rather than rationality of cleaning and shaping needs.

偏移的原因：

- 器械的柔韧性差。器械通过弯曲根管时，受力后趋向伸直，进而切割根管根方的外侧壁和冠方的内侧壁（图 6-5a）。
- 锐利的尖端使根管锉的切割方向不受限制。
- 上下的往复运动。器械在弯曲根管的位置由根管形态决定，不受医师控制。上下往复运动导致器械在同一位置不断切割，使得从中心位置偏移的同时在根管侧壁形成了凹槽（图 6-5a、b）

偏移后可产生以下问题：出现台阶、清洁不充分以及成形不充分，导致

Transportation resulted from:

- inflexible instruments, which straightened as they passed into curves, cutting on the outer wall apically and the inner wall coronally (Fig 6-5a)
- aggressive cutting tips which offered no restraint to file movement from a centred position
- repeated up-down filing motions. In curved roots, the canal, not the operator controls the instrument's position. Recurring up-down filing motions cause the instruments to cut repeatedly in the same place, forming an ever-deepening groove as they migrate from a centred position (Fig 6-5a,b).

This has been a daily reality in practice: ledged and inadequately cleaned canals,

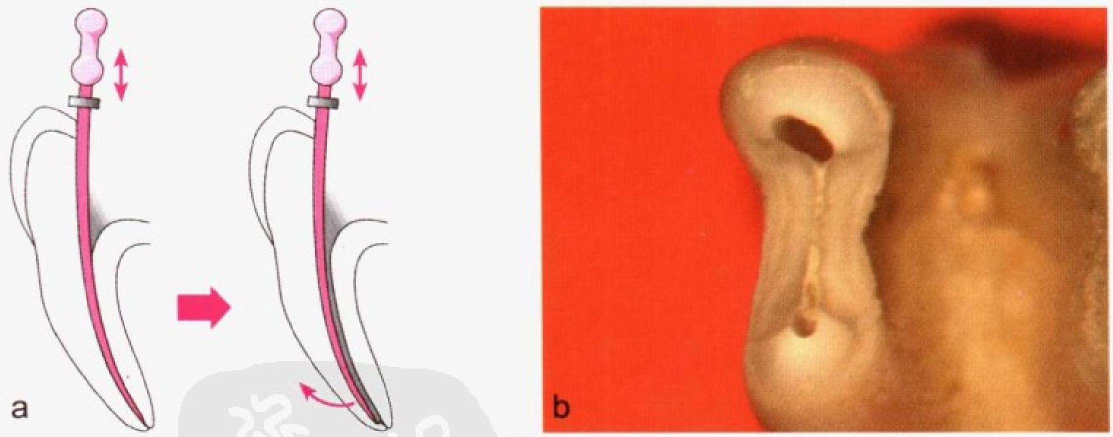


图 6-5　a. 器械从根管长轴的中心位置偏离；b. 柔韧性差的器械在弯曲根管的同一位置不断切割。在上方的根管中，器械从中心位置偏移，根管失去原有形态。在下方的根管采用旋转预备扩大根管，根管仍保持在中心位置

Fig 6-5　(a) Deviation of instruments from a long-axis centred position. (b) The consequences of inflexible instruments being guided by canal curvature to cut repeatedly in the same place. The instrument in the upper canal transported from a centred position and loses shape. The lower canal was prepared bigger by rotation and remains centred.

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不能有效地封闭根管。

应综合考虑以下的两方面的问题: ①根尖的直径到老年仍保持宽大。②为高效机械清洁所需扩大的根管要比用传统器械和传统方法大得多。

inadequately shaped for an effective seal.

Problems were compounded by the realisation that apical canal diameters remain large into old age and that rational enlargement for effective mechanical cleaning may be far greater than possible with traditional tools and motion.

防止偏移

防止偏移的方法包括:

- 抗弯曲扩锉。通常的扩锉动作会使某处根管壁上的切割量比其他地方要多,这一方面是由于没有认识到根管的三维解剖结构,另一方面是由于医师无法控制锉在弯曲根管深部的位置。
- 根据X线片上根管的弯曲度来预弯器械。由于颊舌向上的重度弯曲通常在X线片上无法体现,因此这种二维方向上的预弯也不能完全解决问题,无法阻止颊舌向的偏移。
- 限定根尖扩大的程度。只用小号器械来预备根尖区。但这种方法忽略了根尖部仍有一定的直径以及机械清洁和冲洗根尖部的必要性。遗憾的是,在传统的扩锉动作中,即使是25号不锈钢锉也会在弯曲的根管中发生偏移,导致根管形态预备不规则和

Combating Transportation

Attempts to control transport have included:

- Anticurvature filing. This popular action, in which some walls were filed more than others, failed to recognise three-dimensional anatomy and the reality that the position of a file deep in a curved canal cannot be controlled by the earnest efforts of the dentist at the canal entrance.
- Pre-curving instruments to match radiographic canal curvatures. This two-dimensional solution again denied the unseen, often more severe buccolingual curvature and could not combat transportation.
- Limiting the extent of apical enlargement so that only small instruments reached the root terminus. This strategy disregarded apical canal diameter and the need to open for mechanical cleaning and irrigation. Sadly, even size 25 stainless steel files will transport curved canals when applied in a

清洁不充分。这是因为冲洗针头相对较大，例如一个窄 27 号冲洗针头与45号器械的直径相当。

traditional filing motion, leaving them irregularly shaped and under-cleaned. For reference, a narrow, 27 gauge irrigating needle equates to instrument size 45.

最新的改进方法包括：

- 锉尖几何形态的变化
- 从转动形式预备，包括平衡力操作
- 使用柔韧性更好的金属合金

More recent and rational strategies have included:

- changes in file-tip geometry
- rotational, including Balanced-Force instrument motion
- more flexible metal alloys.

锉尖的几何形态

大多数的根管锉尖端较钝，从锐利的切割区至尖端的过渡也比较平滑。许多锉的切割面也比较平坦——“径向带”（图 6-6），这进一步限制了锉的偏移。

File-tip Geometry

Most endodontic files now have blunt tips and smooth angles of transition from the aggressive cutting area to the tip. Many also incorporate flat outer surfaces - “radial lands” (Fig 6-6) - which further restrict file movement from a central axis.

转动，平衡力切割

自从 1985 年 Roane 阐述了平衡力学操作，K锉的安全性和有效性有了明

Rotational, Balanced-Force Cutting

A dramatic improvement in the safety and efficiency of K-file performance came

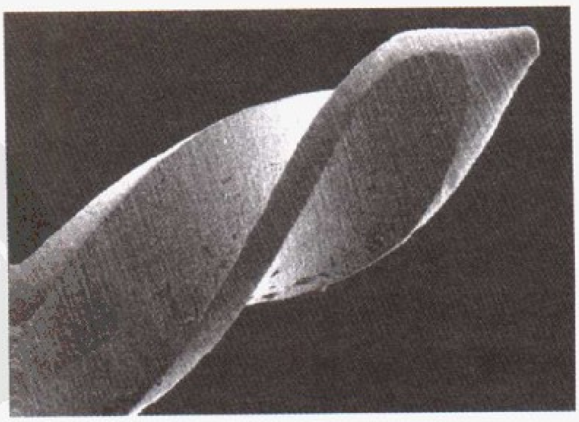


图 6-6　钝头锉有圆形工作头，切割区至非切割区过渡平滑。其外周的径向带也易于将器械保持在根管的中心

Fig 6-6　Non-end-cutting file with its rounded tip and smooth transition from bladed to non-bladed area. Radial lands at the periphery of many files also work to hold instruments centred in the canal.

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显改善。简言之，就是应将锉插入根管，顺时针方向轻轻旋转1/4圈，使切割刃卡在牙本质上（图6-7a）。如果锉旋转过度或用力过大，在退出时可能会锁住，并被扭断，而尖端仍留在原位。

完整的一次切割运动还包括逆时针旋转运动，不过假如锉只是简单的逆时针旋转，那么锉将退出根管而不起切割作用。为了能够切割牙本质，必须在逆时针旋转的同时加压，来平衡其旋出的力量（图6-7b）。小号器械比大号器械所需的力量小，当垂直加压于锉上并旋转时，力量会集中在柄上，直到这个力量和牙本质内受到的阻力平衡。此时可以听到"咔嗒"声，并感觉到牙本质正在被切割。第一次使用的可能会误认为是器械折断。

再次顺时针旋转1/4圈，碎屑进入锉的凹槽，这样就可以除去牙本质碎屑（图6-7c）。检查锉有无损伤后，再次插入，假如可以自由地旋转，则此号码的切割工作完成，可换成大一号的器械。

对那些没有用过平衡力量方法的

with the description of Roane's Balanced-Force motion in 1985. Briefly, the file is gently inserted and rotated a quarter-turn clockwise to engage the blades in dentine (Fig 6-7a). If the file is turned further or harder, it may lock and twist-off during removal, leaving the tip *in situ*.

The cutting stroke involves anti-clockwise rotation. If the file is simply rotated anti-clockwise, it will screw out of the canal without cutting. In order to cut, it must be turned anti-clockwise, whilst pressing (Fig 6-7b) to balance the force with which it wants to back out. This will be smaller with a small file than a large one. As the file is held by vertical pressure and rotated, tension builds in its shank until the energy it contains balances and overcomes the force with which it is being held in dentine. A click is heard and felt as the dentine shears; a truly disconcerting experience at first with every expectation that the instrument has fractured.

Cutting debris is removed by rotating a quarter-turn clockwise once again (Fig 6-7c) to pick up broken dentine which is carried out on the flutes. After wiping and inspection for any damage, the file can be re-inserted and if it now rotates freely, it has cut a circle and done all the work it can; a rational time to move on to the next instrument.

For those with no experience of Bal-

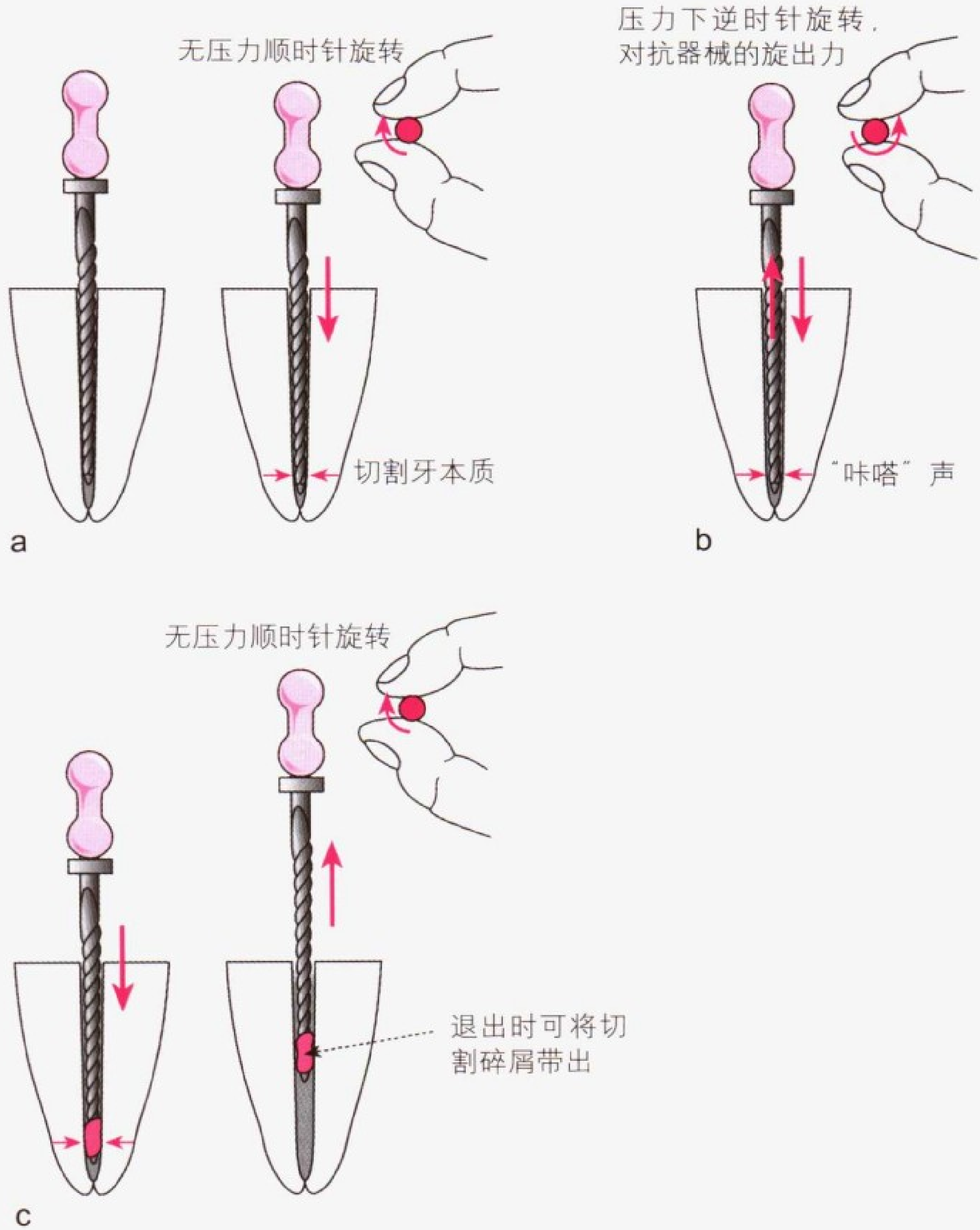


图 6-7 平衡力操作：a. 顺时针轻旋 1/4 圈卡入牙本质；b. 切割动作：逆时针旋转能将锉安全地退出，没有切割力。需要用施加在器械的压力来平衡回退力，阻止器械退回，并切割牙本质。当对牙本质进行切割时，应出现“咔哒”声；c. 再次顺时针轻旋 1/4 圈，碎屑进入锉的凹槽，退出时可将碎屑带出根管

Fig 6-7 The Balanced-Force motion. (a) Engaging dentine with a light quarter-clockwise turn, (b) The cutting stroke: turning anticlockwise safely screws the file out of the canal without cutting. This backing-out force must be-balanced by pushing down on the instrument to prevent its retreat and cut dentine. There is a worrying click as the dentine shears, (c) Clearing cutting debris requires another light quarter-clockwise turn to pick up material on the flutes, and withdrawal to carry it free from the canal.

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人来说，此方法比较安全有效，但应避免过分用力，并克服"咔嗒"声带来的恐惧。这种方法可以将根管预备成同心圆状的环状形态，且几乎不会产生台阶和偏移，这是由于：

- 器械在切割的过程中没有向前推进。
- 可以避免重复的切割动作。

具有柔韧性的金属合金

冶金学的发展带来了材料学的发展，首先是柔韧性更好的不锈钢的出现，然后是镍钛合金的出现。镍钛合金是在20世纪80年代末期被引入牙髓治疗的，它有以下优点：

- 前所未有的柔韧性。
- 可加工成各种各样的形态。
- 可耐受重复弯曲（循环疲劳/工作硬化），可在弯曲根管内旋转，折断的危险性小。

镍钛合金开创了机械预备根管的新时代，并使手用和机用镍钛器械预备时都能达到一致的同心性。

锥度渐增的柔韧镍钛器械能预备出平滑的预定锥度，无需复杂的退出过程。由于不受器械柔韧性的限制，根

anced-Force motion, it will transform manual instrumentation into a safe and efficient process, but it must be practised to avoid excessive force, and to overcome fear of the clicks. The prize is a centred, circular preparation with little risk of ledging and transport because:

- instruments are not driving forward during the cutting phase, and
- repeated cutting strokes are avoided.

Flexible Metal Alloys

Metallurgy has brought other developments, first with more flexible stainless steel, then with nickel-titanium (NiTi) alloys. NiTi was introduced to endodontics in the late 1980s with the benefits of:

- unprecedented flexibility
- the ability to be milled into a variety of conventional and radical new forms
- the ability to withstand repeated flexion (cyclic fatigue/work hardening), and rotate in curved canals with reduced risk of fracture.

NiTi has opened an exciting age of mechanical root canal preparation, with consistent, well-centred preparations achievable by hand, or with engine-driven assistance.

Flexible instruments with greatly increased tapers mill smooth, predetermined tapers by default, without the need for com-

尖区的预备可以更好地适合根管的直径和根管清洁的需要。经过训练的新手同有经验的医师一样，都可以使用此项技术。

plex step back procedures, and apical preparations can be matched to the diameter and cleaning needs of the canal, not the flexibility limits of enlarging tools. Properly trained novices as well as experienced dentists have been empowered.

根管预备的其他进展

Other Advances in Canal Preparation

除了器械性能和操作方面的改进，预备方法的改进也使根管的预备更加简单合理。

Improvements in instrument manufacture and action have not been the only changes to simplify and rationalise canal preparation.

早期开放／冠向下预备

Early Flaring/Crown-down Preparation

现在大多数的技术都是在深入预备前先预备根管的冠1/3。许多方法则完全是从冠方至根尖方向预备，原因如下：

- 大多数感染和坏死物质位于根管的冠1/2。早期清除这些物质，在随后的预备就大大减少了将其带至根尖的可能性，也减少了根管堵塞和术后的急性发作。
- 由于冲洗液只能对冲洗针头下方的一小段进行冲洗，早期开放或是逐步深入的冠向下预备可使针头在早期就能进入根管深部，减少根管阻塞，加强冲洗清洁。

Most techniques now open the coronal third of the canal before working deeper, and many prepare entirely from crown to apex for the following reasons:

- Most of the infected, necrotic material lies in the coronal half of the canal. By eliminating this material early, it is less likely to be carried apically during subsequent preparation, reducing the incidence of blockage and postoperative flare-up.
- Irrigant solutions do not exchange far beyond the tip of the delivery needle. Early flaring or progressive crown-to-apex preparation allows deep entry at an early stage, reducing the risk of blockage and potentiating cleaning.

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- 小号器械早期难以进入根管深部常常被误以为是由于"根尖钙化"引起的，其实是由于器械卡在根管的冠1/3。早期的冠方扩展可使器械进入更深（图5-4）。

冠向下预备的另一优点：由于最后进行根尖预备，因此可以更加安全、精心合理地预备这一重要区域。

- Difficult advance of a small instrument is usually rationalised as "apical sclerosis". The reality is often "hang-up" in the coronal third of the canal, and early flaring frees deeper entry (Fig 5-4).

A crown-down approach also commends that apical instrumentation is the finale, allowing sensitive, interference-free sizing and rational enlargement of this critical region.

保持根管通畅

在预备的过程中，如果没有经常检查通畅性，根管仍然容易阻塞，应该在严密堵塞前使其通畅。

有效保持根管通畅的常用方法是：在预备的过程中，不时地将小号锉插入根管至根尖孔，甚至可以超出1mm，并确保能一直维持这一长度，有效地保持根管通畅。但目前这一方法还存有争议，因为根尖感染物的堵塞可能比小号器械（≤10号）偶尔超出根尖孔的危害性更大，何况小号器械的超出对根尖孔并无扩大作用。在此过程严禁使用较长的钝头大号器械。

保持根管的通畅可以保证根管预备的顺利进行，并使器械在任何时候都可达到所需长度。

Maintaining Patency

Canals are still easy to block if checks are not made frequently and steps taken to free them before they become firmly established.

It has become common practice to advance a small file up to, or even 1mm through, the apical foramen at intervals during preparation to ensure that length is maintained. This action remains controversial, but the dangers of an infected apical plug probably outweigh those of a small instrument (size 10 or lower) occasionally passing through the apical constriction without enlargement. This is not licence to blunder long with larger instruments.

Maintenance of canal patency actually allows preparation to proceed in any sequence desired and gives the option to advance the length of instrumentation at any stage if the need arises.

电子长度测定仪

根管预备的最佳止点位于根管的内外交界处：即牙骨质-牙本质界，或"根尖狭窄"处（图 6-8）。也就是根管末端的0.5～2mm；这在实际应用中非常不精确。

大多数医师采用拍 X 线片和测量器械长度来确定工作长度，这种方法经常会导致预备不足或是预备过度。比较精确的长度测量可以采用电子根尖定位仪，这在临床研究和实际应用中都得以证明。现在的电子根尖定位仪在湿润和干燥的根管中都非常准确（表 6-1）。

Electronic Length Determination

The optimal place to end canal preparation is where inside becomes outside; the cemento-dentinal junction, or "apical constriction" (Fig 6-8). This is said to lie between 0.5 and 2mm short of root end: a very imprecise guideline for practice.

The majority of dentists use radiographs and measured instruments for length determination, and it is likely that inadvertent under- or over-preparation occurs routinely. More accurate length determination can be achieved with contemporary electronic apex locators which have proved themselves in clinical research and experience. Current devices are accurate in wet and dry canals (Table 6-1).

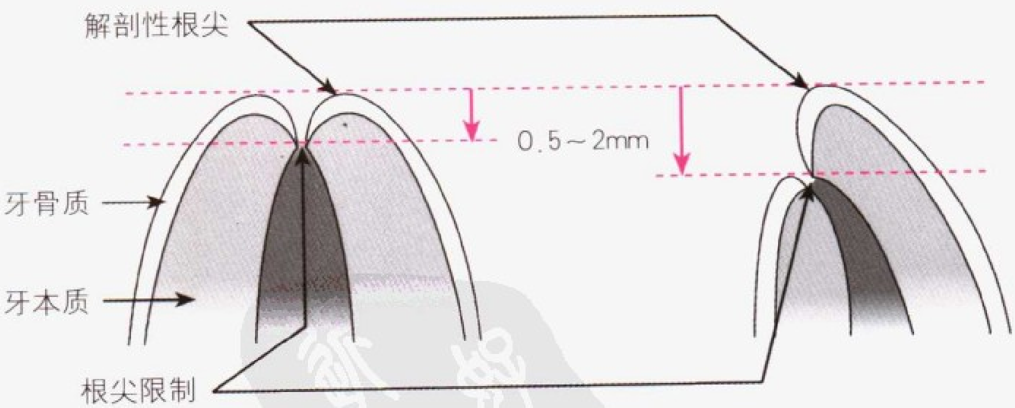


图 6-8 根尖缩窄区，生理性根尖或是牙骨质-牙本质界，是内（宿主防御无法到达）外（宿主防御可以到达）的交界点，也是根管预备的最佳止点

Fig 6-8 The apical constriction, physiological apex or cemento-dentine junction, where inside (inaccessible to host defences) becomes outside (accessible to host defences) - the optimal place to end preparation.

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根尖定位仪虽然比较精确，但只能用来测量长度。而高质量的X线片，还可以辅助诊断。根尖定位仪可以起到辅助作用，但不能完全替代X线片。

For all their accuracy, apex locators can only convey information on length, not the range of diagnostic information available from a good-quality film. They may rationalise and streamline the use of radiographs but they should not do away with them completely.

拍摄高质量的术中X线片应使用专门的X线片夹持器（图6-9），拍摄中微小的偏角可用来分开牙根。

Good-quality mid-treatment films can be secured with a dedicated film holder (Fig 6-9), separating individual roots by exposing at a slight off-angle.

表6-1 湿润和干燥根管均可使用的电子根尖定位仪
Table 6-1 Some electronic apex locators which perform well in wet and dry canals.

Apit （Osada）
Apex Finder AFA （Analytic）
Justy Ⅱ （Panadent）
Raypex4 （VDW）
Root ZX （Morita）

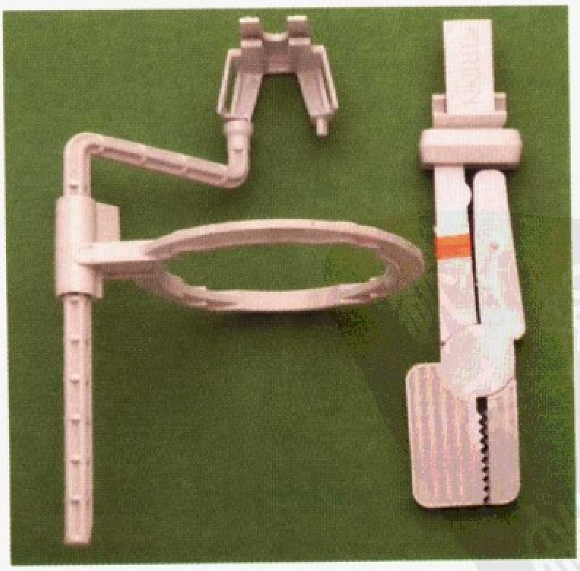


图6-9 Rinn Eddo-Ray和Snap-a-Ray胶片夹持器可保证术中所拍摄的影像不变形
Fig 6-9 Rinn Endo-Ray and Snap-a-Ray film holders for undistorted mid-treatment images.

根管预备前的准备工作

润滑剂的使用、大块组织的去除和钙化根管的处理第 5 章已有叙述。

无论使用哪一种根管预备技术，根管的初步开放都有助于根管预备。通过标准 K 锉 15～35 号可实现根管的初步开放。方法为将锉快速插入根管，在退出之前逆时针旋转。然后对开放后的根管进行冲洗，及通畅性检查，最后进行预备。

根管预备技术

在以下章节中将讲述一些现在常用的预备方法：

- ISO 标准器械的手工预备。
- 大锥度器械的手工预备。
- 有锥度或无锥度器械的机动（旋转）预备。

ISO 标准器械的手工预备

ISO 标准器械仍然占有一席之地。现在许多大学的本科教学中仍然使用"逐步后退法"，"二次开放法"或是ISO 标准锉的其他预备方法（图 6-10）。

Getting Ready for Preparation

Lubrication, gross tissue removal and negotiation to length were discussed in Chapter 5.

Regardless of the preparation technique to be used, it is helpful to do some initial opening by quickly running through standard K-files size 15-35, inserted passively, and rotated anticlockwise before withdrawal. The opened canal is then irrigated, and checked for patency as definitive preparation begins.

Techniques for Canal Preparation

In the following paragraphs, some contemporary methods will be reviewed for:

- manual preparation with ISO instruments
- manual preparation with increased taper instruments
- engine-driven (rotary) preparation with tapered and taperless instruments.

Manual Preparation with ISO Instruments

ISO instruments still have a place, and "stepdown", "double flare" or variants of these techniques with ISO files remain standard teaching in most undergraduate programmes (Fig 6-10).

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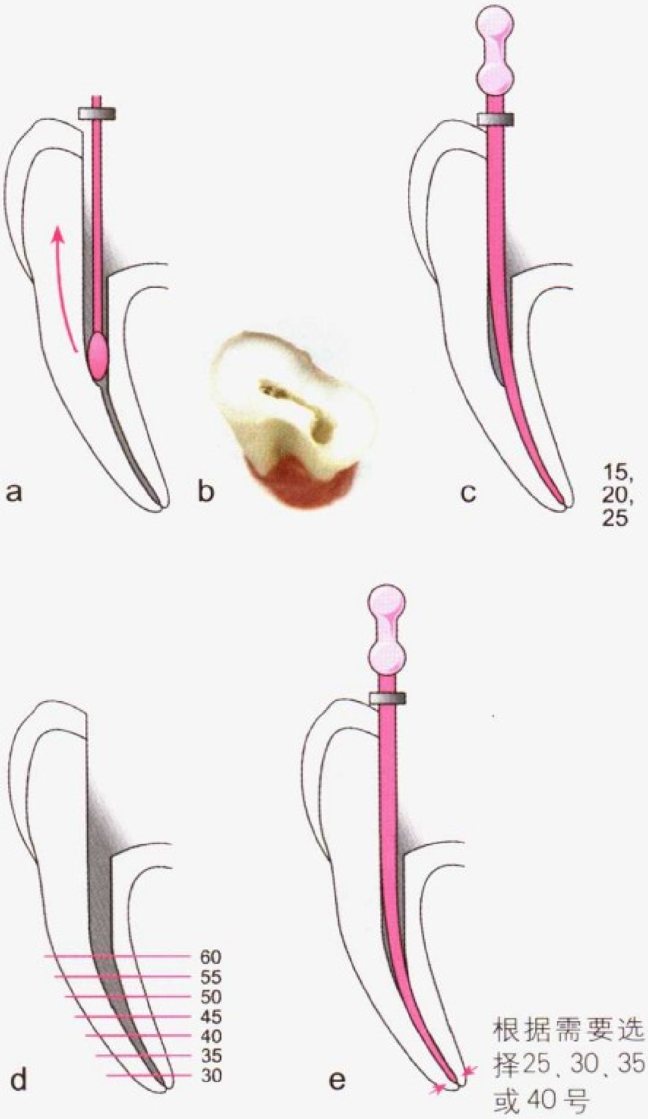


图6-10 ISO标准器械逐步后退或二次开放法预备。a. G钻开放根管较直的冠方部分(第一次开放)，随着器械号码的增大，插入的深度逐渐变浅，远离根分叉进行预备，可以避免根分叉侧壁过细；b. 扩大时由于粗心导致的根分叉侧壁过细或者条形穿孔；c. 根尖初步扩大时可到25号，便于根管冲洗，但最后预备要等到根管全段完全开放；d. 开放根管的根尖部分(二次开放)，并与冠方连成平滑的弧线。预备时由根尖向冠方，或者冠方向根尖，每次增加1mm，通过逐步后退或逐步前进来完成预备。e. 最后一步进行根尖区修整。用锉来感觉测量根管的直径，使根尖区的预备更加合理

Fig 6-10 Stepdown or Double-Flare preparation with standard ISO instruments. (a) Flaring the straight, coronal part of the canal (first flare) with Gates Glidden drills. Increasing sizes are inserted to lesser depths, and all are directed away from furcal walls to prevent over-thinning, (b) Over-thinning and near stripperforation from careless enlargement. (c) Initial apical enlargement to arbitrary size 25 opens the apical region for irrigant exchange, but definitive preparation must wait until the canal is properly flared, (d) Flaring the apical part of the canal (second or double flare) to blend smoothly with the coronal area. This can be achieved by stepping back from the apex in lmm increments or enlarging from coronal to apical, (e) Revision of the apical preparation as the finale. Files act as feeler gauges of canal diameter, making apical preparation rational.

根管的冠部开放

- 在进入根管后，用K锉进行探查和根管初步开放。使用2，3，4号G钻对较直的冠1/2～2/3进行开放，插入时不加力，退出时轻轻地直接贴着根管壁上。在多根牙，提拉时需远离根分叉处的侧壁，防止造成根分叉处过薄或者穿孔（图6-10a，b）。随着器械号码的增大，插入的深度应逐渐变浅，预备完成后进行根管冲洗，并检查通畅性。

Coronalflaring

- After access, exploration and initial passive opening with K-files, the straight, coronal half to two-thirds of the canal is opened with Gates Glidden drills 2, 3 and 4, inserted without force and directed lightly against canal walls on withdrawal. In multi-rooted teeth, they are directed away from furcal walls which are at risk of over-thinning and perforation (Fig 6-10a,b). Increasing sizes are inserted to shallower depths, and the canals irrigated and checked for patency.

工作长度的测量

- 可通过电测、X线片或是两者结合的方法进行测量。在根管冠部开放后测量工作长度的优点是：根尖的缩窄点至冠方标志点之间的距离几乎不会改变。如果在工作长度测定之后再进行冠部开放，从根尖缩窄点至冠方标志点之间的长度就会缩短。如果按照预定的长度对器械进行精确测量，无意之中就会使根管预备过长，使根尖的止点消失，并导致超充。

Working length determination

- This can be achieved electrically, radiographically or by a combination of methods. The advantage of determining working length after coronal flaring is that the distance from apical constriction to coronal reference point is less likely to alter. If coronal flaring happens after working length determination, the distance from apical constriction to coronal reference point shortens. Studiously measuring instruments to the previously determined working length, the canal is inadvertently prepared long, with no apical stop and a dissatisfying overfill.

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根尖的初步扩大

- 使用柔和的平衡力法预备至工作长度。在这个预备过程中，无法测定根管的直径，根尖区应初步扩大至25号（图6-10c）。使用平衡力法操作，可以避免所有重度预备弯曲根管预备过程中的严重偏移。

根管深部开放成形

- 用大号K锉采用平衡力操作逐步后退来开放深部根管，每次后退0.5～1mm，直至60号（图6-10d）。当退出的速度较快以及器械可在根管内自由旋转时，表明可以换下一号器械，同时应进行根管冲洗和通畅性检查。

- 也可以由冠向下逐渐进入，用60号锉从2号GG钻可以到达的位置开始，向根尖逐渐推进。

根尖直径的测量和修整

- 根管完成上述开放后，就可以开始测量根尖直径。这一过程可使用柔韧性较好的镍钛锉。镍钛锉由于柔韧性较好，可以用来扩大

Initial apical enlargement

- The canal is now prepared to working length with gentle Balanced-Force motions. There is no possibility of gauging canal diameter at this stage of the preparation, and the apical region is opened initially to an arbitrary size 25 (Fig 6-10c). With Balanced-Force motion, this is small enough to avoid serious transport in all but the most severely curved canals.

Flaring for deep shape

- The canal is now flared with larger K-files, stepping back with Balanced-Force motion to size 60 at 0.5~1 mm intervals (Fig 6-10d). Step back occurs rapidly and a freely rotating instrument marks rational progress to the next instrument which is accompanied by irrigation and patency checks.
- There is no reason why this flaring cannot be developed crown-down, starting where the Gates 2 reached with a size 60 file and working progressively apically.

Apical gauging and revision

- The canal properly flared, there is now an opportunity to gauge apical canal diameter. This phase is best completed with flexible NiTi files which will al-

根尖处的根管，满足清洁要求（图 6-10e）。

- 插入 25 号锉，通常可以无阻力地达到工作长度。但有时，30号和 35 号器械通常也能轻松地达到工作长度。根尖直径测量的过程一直持续到有阻力为止，然后再使用平衡力法切割根尖 1～2mm的牙本质。在锉退出时，除了有“咔嗒”声以及切割的感觉，还可在锉尖上看到切割的牙本质（图 6-11）。这时根尖合理地变大。

通常磨牙根管用这种方法扩大到 40 号，就可使根尖保持清洁，并有良好的根尖狭窄来进行根管充填。

最后检查

- 主尖锉的X线片或是电测法有助于最后的根管预备。

low the canal to be enlarged for its cleaning needs without the constraints imposed by inflexibility (Fig 6-10e).

- The size 25 file is inserted, and usually passes to length without resistance. This is often surprisingly followed by size 30 and 35 instruments which loosely sweep to length. This process of apical gauging continues until resistance is felt, and Balanced-Force motion cuts dentine in the apical 1-2mm. In addition to the clicking, cutting sensation, cut dentine will be visible on the tip of the file as it is withdrawn (Fig 6-11). Rational apical enlargement.

Molar root canals are often prepared to size 40 by this method, and have clean apices with good resistance form for obturation.

Final checks

- A radiographic or electronic check with master files in place can be helpful to



图 6-11　在根尖修整时，锉的凹槽内可见切割的牙本质，由此可以测量出根尖的直径。根尖修整可使根管的清洗更加充分，并且可以确定合适的主锉

Fig 6-11　Flute-loading during apical revision. Apical diameter is known because it is clear when dentine has been cut; cleaning is improved and master cone fit is predictable.

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- 所有用来加压充填的器械必须先在根管内预试，确保能对根管全段的充填材料进行加压。

大锥度器械的手工预备

大锥度的镍钛GT手用锉（GT锉：Maillefer/Dentsply）可使手工预备更为简单。和镍钛GT手用锉一致的特点：

- 锥度为ISO标准锉的3，4，5，或6倍（表6-2），可进行平滑、理想的预备。
- 20号大小的，无刃尖。
- 最大切割直径为1mm（100号），当锥度增大，其切割的区域反而减小（图6-12），可以保护锉的刚性，并防止过多地去除冠方牙本质。
- 较大的梨形手柄能提供较大的旋转切割力，对抗旋转过程中强大的外部阻力。

finalise preparation.

- All condensing instruments should then be tried in the canal to ensure that they will be able to pack the root filling throughout its length.

Manual Preparation with Increased-taper Instruments

Manual preparation is simpler and more consistent with NiTi Greater Taper hand files (GT files: Maillefer/Dentsply). These have:

- 3, 4, 5 or 6 times the standard file taper (Table 6-2) to deliver smooth, predictable preparations
- size 20, non-cutting tips
- a maximum bladed diameter of 1 mm (size 100), making the active region shorter as taper increases (Fig 6-12) to limit unhelpful file rigidity and excessive coronal dentine removal
- over-sized, pear-shaped handles for relatively high rotational cutting forces and to balance the strong outward force

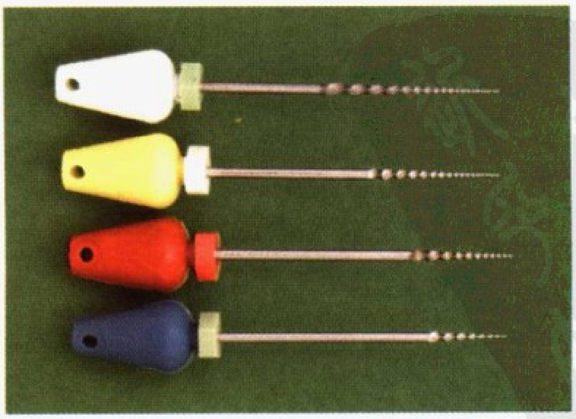


图6-12 GT手用锉锉尖为20号，最大切割直径为1mm的锉，并带有较大的梨形手柄和可进行顺时针平衡力操作的反向锉刃
Fig 6-12 GT hand files with common, size 20 tips, maximum bladed diameter of lmm, oversize pear-shaped handles and blades milled in reverse for clockwise Balanced-Force motion.

• 反向锉刃使得顺时针旋转就可以进行平衡力操作。

通常只需用一根器械就可完成预备。从冠方至根尖预备，可形成自有的大小和锥度，达到"最后成形"的目的。可根据牙根大小和弯曲度来选择"最后成形"器械（表 6-2）。

during rotation

• blades milled in reverse to deliver Balanced-Force motion by clockwise rotation.

Preparation is usually completed with one instrument, working from crown to apex to create a preparation of its own size and taper, the "final shaping objective". Root size and curvature dictate "final shaping objective" instrument selection (Table 6-2).

标准预备

初步进入

• 根管预备前的准备工作和初步开放同前。

Typical preparation

Initial entry

• Negotiation and passive opening is recommended, as previously.

冠向下成形

• 用最后成形锉采用顺时针旋转的平衡力法来进行预备（图 6-13a），器械应经常取出和清洁，检查有无缺陷。然后进行根管冲

Crown-down shaping

• Preparation follows with the final shaping objective file in clockwise Balanced-Force motion (Fig 6-13a). The instrument is removed frequently,

表 6-2 GT 手用锉和最后成形的牙齿

Table 6-2 Greater Taper (GT) hand files and final shaping objectives.

手柄颜色	锥　度	最后成形的牙根
白色	0.06（3 倍 ISO 标准）	下颌切牙，2个根管的前磨牙，其他细小及重度弯曲根管
黄色	0.08（4 倍 ISO 标准）	其他任意牙
红色	0.10（5 倍 ISO 标准）	其他任意牙
蓝色	0.12（6 倍 ISO 标准）	上颌中切牙，下颌磨牙的远中根，上颌磨牙的腭根

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洗并检查根管的通畅性。

wiped and inspected for faults and the canal irrigated and checked for patency.

- 当到达根尖1/3时，测量工作长度，然后按照测量长度进行预备。
- 也可用0.12，0.10，0.08，及0.06锥度的锉由冠向下逐步进行预备。

- Working length is determined as the apical third is reached, and the preparation continued to the determined length.
- Alternatively, the .12, .10, .08 and .06 files can be used in crown-down sequence.

根尖测量

- 将标准镍钛锉器械插至工作长度测量根尖直径，然后按前面的方法进行根尖区的修整。
- 在根尖狭窄的根管中，应逐步插入20，25，30，35，40号的锉来确保根尖锥度的平滑扩大（图6-13b）。在这种情况下预备的并不是传统意义上的止点，而是一个锥度迅速增大的"根尖控制区"。其优点可能是，如果器械很长，用来限制超充的阻力点也不会失去。相反，在传统预备中，ISO标准锥度器械过长会导致阻力点的消失（图6-13c）。

Apical gauging

- Standard NiTi instruments can then be inserted to working length to gauge canal diameter and revise the apical preparation, as previously.
- In canals which are narrow apically, passive insertion of files 20, 25, 30, 35, 40 will confirm the development of smooth apical taper (Fig 6-13b). The apical preparation in this circumstance is not a traditional stop, but a rapidly tapering "apical control zone". The likely advantage is that if instrumentation was long, resistance to overfill has not been lost. By contrast, straying an ISO tapered instrument long in traditional preparation loses all resistance form (Fig 6-13c).

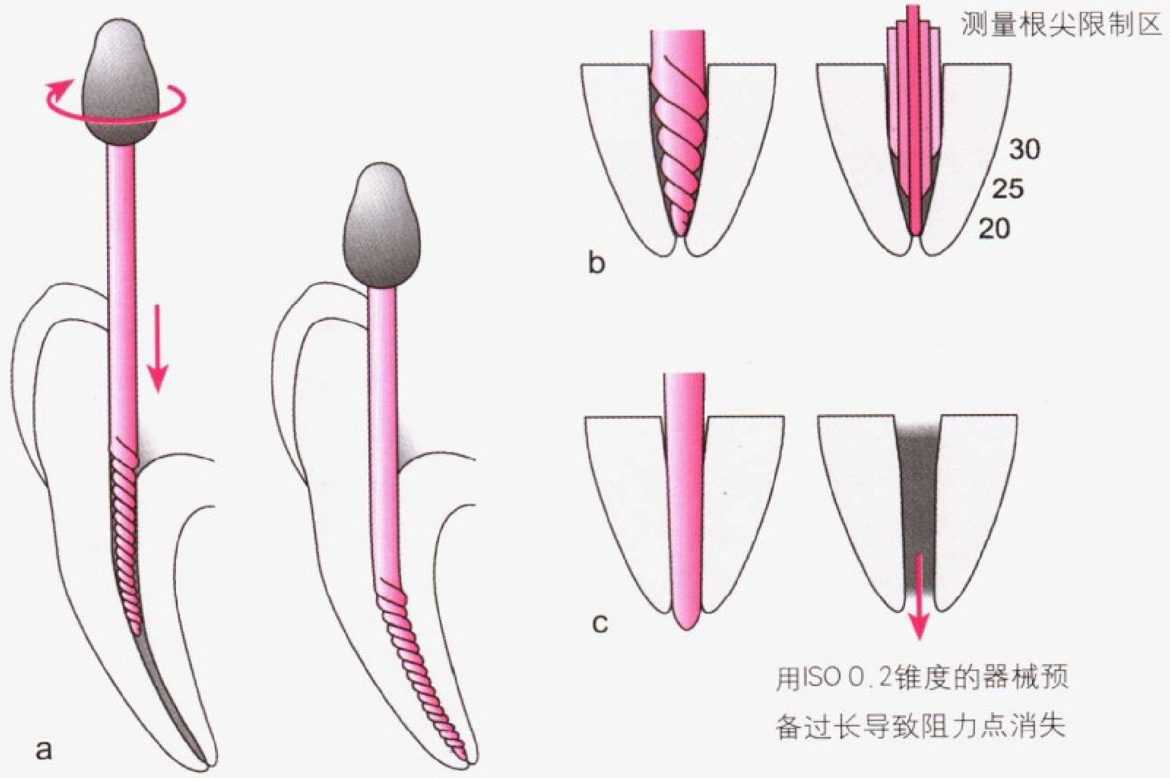


图 6-13 a. 使用最后成形的 GT 锉进行冠向下预备。b. 根管预备和根尖控制区的根尖测量，即使器械超出根尖孔，根尖控制区也能保持根尖部的阻力。c. ISO 标准锥度器械超出根尖孔后，长度无法控制

Fig 6-13 (a) Crown-down preparation with the final shaping objective GT file. (b) Apical gauging of canal preparation and apical control zone. The apical control zone preserves apical resistance form even if the instrument is over-extended. (c) Loss of length control with an over-extended ISO tapered instrument.

有锥度及无锥度镍钛器械的机用根管预备

自20世纪90年代以来的报道，镍钛旋转器械成为根管扩大必不可少的工具。

在详细回顾镍钛旋转器械之前，先了解一下其一般特性。

Engine-driven Preparation with Tapered and Taperless NiTi Instruments

Since their introduction in the early 1990s NiTi rotary instruments have become indispensable tools for canal enlargement.

Before reviewing systems in greater detail, some generalities should be noted.

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关于镍钛旋转器械的需知内容

- 器械进入的路径应呈直线。镍钛器械不可能达到想象中的弯曲程度，因此必须建立合理的进入路径。
- 镍钛器械不能用来钻孔或探查路径，它们只是扩锉工具——只能用来扩大通畅的根管。因此在旋转进入未知路径时，施加一定的压力，这种压力可能导致锉尖的突然弯曲或误入其他解剖结构复杂的区域，例如重度弯曲的根管和融合根，从而发生危险。并很可能导致器械折断。因此应全面仔细探查根管系统，并在旋转扩大前进行初步开放。
- 旋转速度和推进速度十分严格的。旋转速度应与产品说明书一致，最好使用电动马达和减速手机。器械应能平滑地进出根管。推进速度是指器械进入根管的速率。镍钛器械推进时应采用小幅度的上下来回运动来"啄"牙本质（而非"咬"），所施加的力不应超过用锐利铅笔写字的力度。强力推进会锁死并损害器械。在冲洗和检查之前，器械在根管内停留的时间不应超过5s。

What We All Need to Know about Rotary NiTi

- Access must be straight. There is no possibility to bend NiTi instruments for a favourable flightpath, and access must be properly defined and revised.
- They are not boring tools or path-finders, they are reamers - instruments for enlarging an existing hole. Grinding a path into the unknown demands pressure, and may lead to abrupt tip bending or dangerous blundering into areas of complex anatomy, severe curvature or confluence; a recipe for instrument fracture. Canal systems should be thoroughly explored and passively opened before rotary enlargement.
- Speed and feed are critical. Speed of rotation should be known, consistent and in accordance with the manufacturer's instructions. This is best delivered with an electric motor and speed-reducing handpiece. Instruments should be running smoothly throughout their advance and withdrawal from the canal. Feed refers to the rate of advance of a cutting tool into the canal. NiTi instruments should nibble (not bite) dentine, and should be advanced with low-amplitude up-down pecking motions, applying no

- 扭矩控制电机可以进一步减少锁针的危险和器械的超负荷。当接近扭矩极限时，电机会自动停止旋转甚至反转。
- 器械应保持连续运动。尽管镍钛器械可以抵挡旋转疲劳，但是如果器械被卡住，应力就会集中。在某一水平上进行一次旋转，就可以产生一个同心圆，在同一水平重复进出或停留只会徒劳无益。
- 应对器械使用次数进行记录。与不锈钢器械不同，镍钛器械在折断之前几乎没有什么迹象。因此必须记录使用次数，使用一定次数的病例后（如 10 次），应及时丢弃。在疑难病例中，器械的使用不应超过一次。
- 如果感觉到器械出现了问题，应立即退出，并用传统器械重新进行预备。
- 应不断学习。仅阅读一本说明手册远远不够，新手应该注意：

more force than with a sharp pencil. Heavy advance can lock and shear instruments. No tool should be in the canal for longer than five seconds before withdrawal for cleaning and inspection.

- Torque control motors can further minimise the risk of locking and overload, stopping forward rotation or even backing out if a tool is used close to its torsional limit.
- Instruments should be constantly moving. Although NiTi withstands cyclic fatigue, it is concentrated in one place if an instrument is held still. One rotation at a given level cuts a concentric circle - repeated entry or dwelling at length brings no benefit.
- Instruments must be tracked. Unlike stainless steel instruments, NiTi rotaries can show few signs of stress before fracture. Systems must be in place to log and discard tools which have been used in a specified number of cases (usually ten). Particularly challenging cases should be credited as "more than one use".
- If something feels "wrong", NiTi rotaries should be withdrawn and the canal re-established with conventional instruments.
- There is a learning curve. Reading a manual is not enough, and new NiTi

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－学习相关课程

－进行离体牙的模拟操作

－从简单的病例开始

以下是有锥度和无锥度镍钛旋转系统的列表（表6-3）。

users must:

- undertake a hands-on course
- practice with extracted teeth
- start on easy cases.

A range of tapered and non-tapered rotary systems are available (Table 6-3).

有锥度的镍钛旋转预备系统

所有的系统均包括：

• 大锥度器械。

• 冠向下预备方法。

• 最后进行根尖预备。

所有预备中均包括：

• 频繁大量的次氯酸钠冲洗。

• 根管通畅性检查。

• 采用凝胶润滑剂减少摩擦力，使器械容易进入。

Tapered NiTi Rotary Systems

All of these incorporate:

• instruments of increased taper
• crown-down preparation
• apical preparation as the finale.

All involve:

• frequent, high-volume irrigation with sodium hypochlorite
• patency checks
• gel lubricants to cut down friction and ease instrument glide-paths.

1．GT旋转系统

GT旋转系统由手用GT系统发展

1. Rotary GT

Developed from the hand GT system,

表6-3 有锥度和无锥度镍钛旋转器械列表

Table 6-3 A range of tapered and taperless NiTi rotary systems.

有锥度	GT系统	GT锉（Dentsply）
	0.06锥度系统	K3（Kerr） ProFile（Dentsply）
	642系统	HERO 642（MicroMega） Flexmaster（VDW）
无锥度	渐进锥度系统	ProTaper（Dentsply） Lightspeed（Lightspeed Technologies）

而来，其预备过程更快更省力（图 6-14）。

标准预备（图 6-15）

- 根管预备前的准备工作和初步开放同前。
- 用 5 000rpm 的速率用 G 钻或 0.12 锥度的 GT 锉开放根管（图 6-15a）。
- 选择最后成形目标器械以 150rpm的转速稳定推进（不是上下移动），时间不超过 5s。
- 退出器械，清洁和检查有无损坏，然后冲洗根管，检查根管通

rotary preparation is quicker and less physically demanding (Fig 6-14).

Typical preparation (Fig 6-15)

- Negotiate and passively open the canal.
- Enlarge the orifice with Gates Glidden drills or the. 12 GT file running at 5,000 rpm (Fig 6-15a).
- Select the final shaping objective instrument and advance steadily (not pecking up and down) at 150rpm for not more than five seconds.
- Remove the instrument for cleaning and damage inspection, canal irriga-



图 6-14　标准配置包括 4 根 GT 旋转锉，结构与手用器械相同

Fig 6-14　A standard set of four GT rotary files, sharing dimensions with hand-versions.

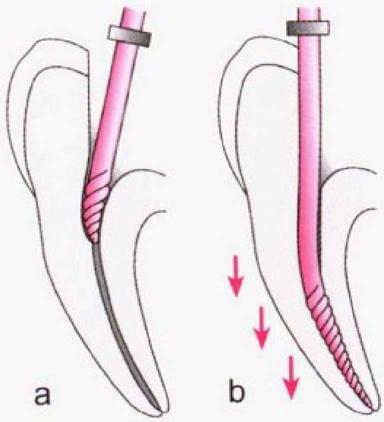


图 6-15　标准的 GT 旋转预备。a. 使用 GT 0.12 锥度的锉开放根管冠方；b. 使用最后成形锉进行根管末端的预备。如果有必要，可再次使用这 4 种器械由冠向下进行预备

Fig 6-15　Typical GT rotary preparation, (a) Coronal flaring with the GT .12 taper file, (b) Preparation to root-end with the final shaping objective file. Again, all four instruments can be used in crown-down sequence if desired.

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畅性。

- 继续向根尖推进，到达工作长度（图6-15b）。
- 根尖直径测量同手用GT器械，但可使用35，50和70号的辅助锉进一步旋转扩大。

tion and patency check.

- Continue to progress apically until working length is reached (Fig 6-15b).
- Apical gauging is exactly as described for the manual GT preparation, but further rotary enlargement is possible with accessory files of tip size 35, 50 and 70.

2. 0.06锥度系统

锥度为0.06，是0.02 ISO标准锥度的3倍。标准配置包括40～15号的整套器械（图6-16），使用时以150rpm的转速进行冠向下预备。

2. .06 tapered systems

Three times the ISO taper, a standard set contains instruments of tip size 40-15 (Fig 6-16), applied in a crown-down sequence at 150rpm.

标准预备（图6-17）

- 根管预备前的准备工作和初步开放同前。
- 使用40号器械，轻轻地上下运动，逐步推进，时间不超过5s。需旋转退出，然后擦洗并检查是否有损坏。
- 根管冲洗和通畅性检查。

Typical preparation (Fig 6-17)

- Negotiate and passively open the canal.
- Advance the size 40 instrument with gentle up-down pecking motions for no more than five seconds. Withdraw the instrument still running, wipe and inspect for damage.
- Irrigate the canal and check patency.



图6-16 0.06锥度器械的标准配置，锥度为ISO标准器械锥度的3倍，含有40~15号器械

Fig 6-16 A standard set of .06 taper instruments, with three times the ISO taper and tip sizes 40-15.

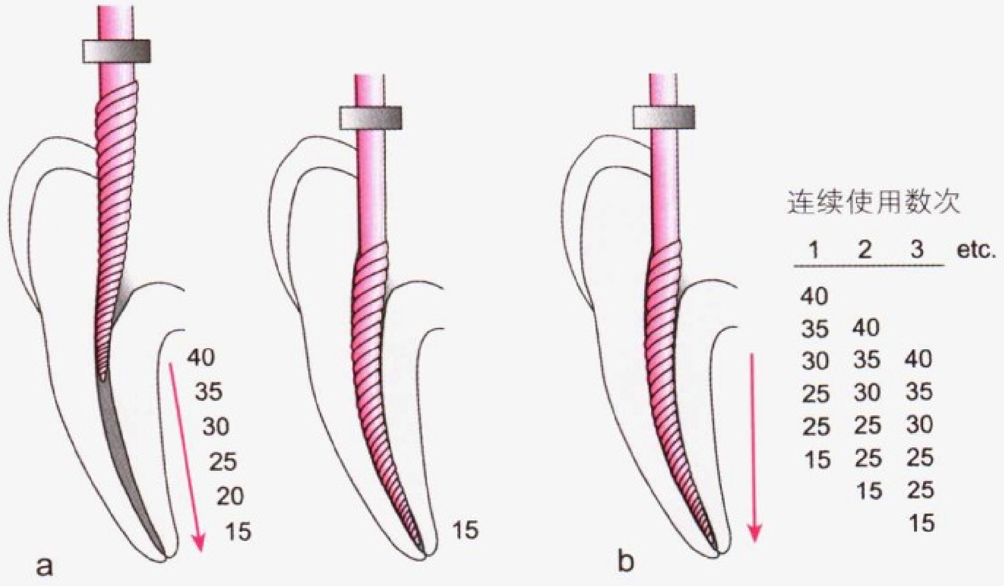


图 6-17　标准 0.06 锥度预备。a. 从 40 号器械开始进行冠向下预备；b. 需多次使用这套器械才能到达工作长度

Fig 6-17　Typical .06 taper preparation, (a) Crown to apex preparation, starting with the size 40 instrument, (b) More than one passage through the series may be needed to reach working length.

- 重复使用 35，30，25，20 和 15 号器械重复预备直至根尖 2mm 内（图 6-17a）。
- 经过多次预备才能达到应有的深度（图 6-17b），需有一定的耐心，加力时需轻微。
- 手用镍钛器械进行根尖直径的测量和扩大，建立根尖止点，或者用 0.06 锥度镍钛旋转器械对根尖限制区进行 0.06 锥度的预备。

3．642 系统

用不同大小和锥度的锉来完成冠向下预备。标准配置（图 6-18）包括

- Repeat with the size 35, 30, 25, 20 and 15 instruments until the apical 2mm is reached (Fig 6-17a).
- More than one passage through the series may be needed to reach this depth (Fig 6-17b), demanding patience and light touch.
- Apical diameter can then be gauged and enlarged to create a stop with standard NiTi hand files, or with .06 taper NiTi rotaries to create a fully .06 tapered preparation with an apical control zone.

3. 642 systems

Crown-down preparation is achieved by varying tip size and taper. A standard kit

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30～20 号三种，每个号码中均会有0.06，0.04和0.02锥度的锉。0.06锥度通常用来开放根管的冠1/2，0.04锥度来开放根尖2mm以上的根管，而0.02锥度进行根尖2mm以内的预备。

(Fig 6-18) contains .06, .04 and .02 tapered instruments in tip sizes 30-20. Generally, .06 tapers open the coronal half, .04 tapers shape to within 2mm of working length, and .02 tapers finish apically.

标准预备（图6-19）

• 根管预备前的准备工作和初步

Typical preparation (Fig 6-19)

• Negotiate and passively open the canal.

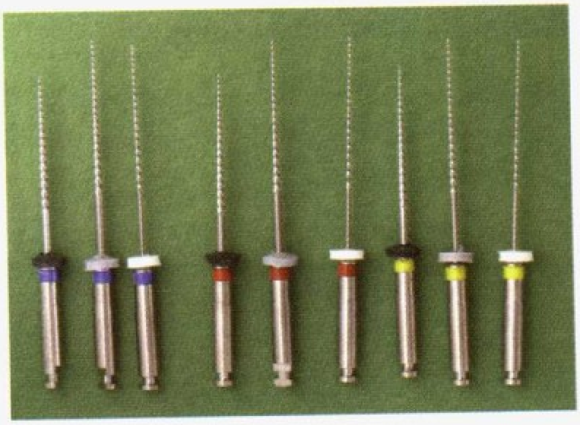


图6-18 642系统的器械中均含有0.06，0.04，0.02锥度的锉，号码为30~20

Fig. 6-18 642 systems with .06, .04 and .02 tapered instruments in a range of tip sizes.

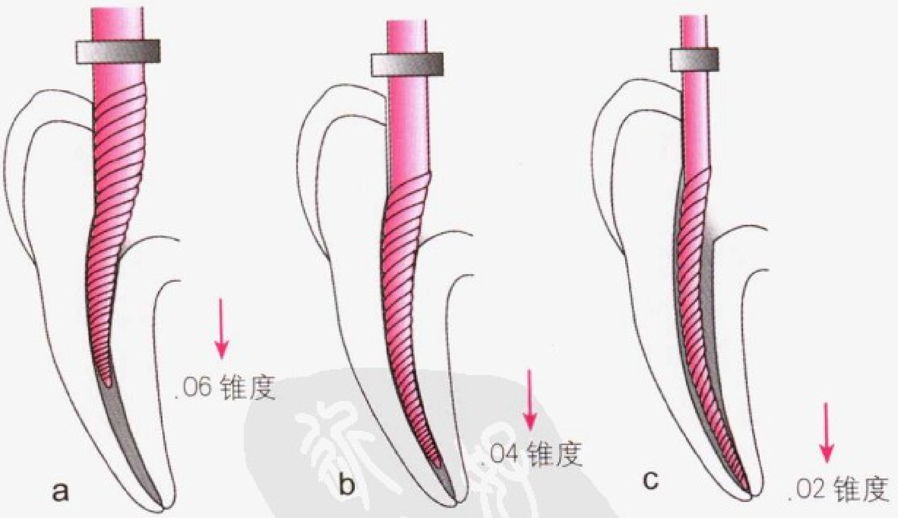


图6-19 典型的642预备。a. 0.06锥度预备根管的冠1/2和冠2/3；b. 0.04锥度预备根尖2mm以上的根管；c. 用手用或者是0.02锥度的旋转器械进行根尖测量和止点预备

Fig 6-19 Typical 642 preparation, (a) .06 taper preparation for the coronal half to two-thirds of the canal, (b) .04 taper preparation to within 2mm of working length. (c) Apical gauging and stop preparation, either by hand or with .02 tapered rotaries.

开放同前。
- 对于宽大的直根管，可从 30 号 0.06 锥度的锉开始，使用轻力在300～600rpm的转速下上下运动逐步推进，扩大根管的冠1/2或冠 2/3（图 6-19a）。
- 冲洗根管，通畅性检查。
- 使用 30 号，0.04 锥度的锉预备根尖 2mm 以上的区域（图 6-19b）。
- 根尖测量和止点预备可用镍钛手用器械或 0.02 锥度的旋转器械（图 6-19c）。

- For a wide, straight canal, commence with the size 30 .06 taper, advancing with light pecking motions at 300-600rpm to enlarge the coronal half or two-thirds of the canal (Fig 6-19a).
- Irrigate and check for patency.
- Continue with the size 30 .04 taper to within 2mm of working length (Fig 6-19b).
- Apical gauging and stop preparation can be completed with NiTi hand instruments or .02 taper rotaries (Fig 6-19c).

较细或较弯曲的根管预备应从25或 20 号器械开始。642 系统可对所有根管进行预备。改变锉尖的直径和锥度，可以避免器械使用过度及应力集中。

In finer or more curved canals, preparation may commence with the size 25 or 20 series. The 642 systems offer considerable versatility in approaching canals of all configurations. Changing tip diameter and taper avoids any instrument doing too much work and becoming over-stressed as the case develops.

4. 渐进锥度系统

除了固定锥度系统，还有渐进锥度系统。渐进锥度器械的工作区含有一系列的锥度。标准配置的尺寸见表 6-4 和图 6-20。

4. Progressively Tapered Systems

In addition to the fixed-taper systems, instruments are available which incorporate a range of tapers in their active region. A standard kit with details of instrument dimensions is shown in Table 6-4 and Fig 6-20.

标准预备（图 6-21）

- 根管预备前的准备工作和初步

Typical preparation (Fig 6-21)

- Negotiate and passively open the canal.

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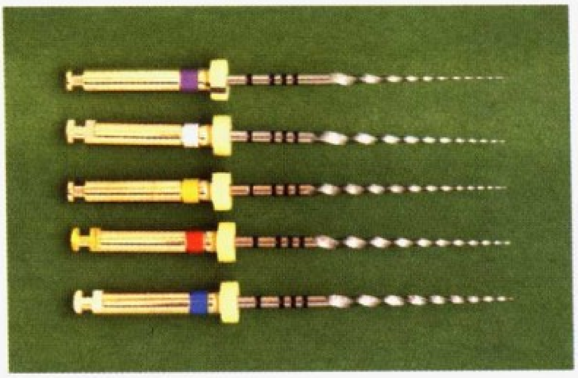


图 6-20 渐进锥度器械的标准配置

Fig. 6-20 Standard kit of progressively tapered instruments.

表 6-4 渐进锥度器械的标准配置和它们的尺寸

Table 6-4 Standard kit of progressively tapered instruments and their dimensions.

器　械	尖端直径	最大直径	锥　度
Shaper1	.185mm（18.5号）	1.19mm（119号）	从尖端的0.02至最宽处的0.11
Shaper2	.20mm（20号）	1.19mm（119号）	从尖端的0.04至最宽处的0.115
Finisher1	.20mm（20号）	1.13mm（113号）	从尖端的0.07至最宽处的0.05
Finisher2	.25mm（25号）	1.2mm（120号）	从尖端的0.08至最宽处的0.05
Finisher3	.30mm（30号）	1.2mm（120号）	从尖端的0.09至最宽处的0.05

开放同前。

- 从Shaper 1开始冠向下预备，轻轻上下移动逐步推进，时间不超过5s（图6-21a）。
- 根管冲洗和通畅性检查。
- 用Shaper 1和2预备至根尖上方1～2mm。
- 用标准镍钛手用器械测量根尖直径（图6-21b）。
- 根据根尖直径的大小，来选择使用Finisher 1（尖端直径为20号），Finisher 2（尖断直径为25号）或Finisher 3（尖端直径为30号）（图6-21c）。

- Crown-down preparation begins with the Shaper 1, advancing with light in-out pecking motions for no more than five seconds (Fig 6-2la).
- Irrigate and check patency.
- Continue with the Shaper 1 and 2 until the apical l-2mm are reached.
- Gauge the apical diameter with standard NiTi hand files (Fig 6-2 lb).
- According to the apical diameter, preparation is completed with the Finisher 1 (tip diameter size 20), 2 (tip diameter size 25) and 3 (tip diameter size 30) (Fig 6-2 lc).

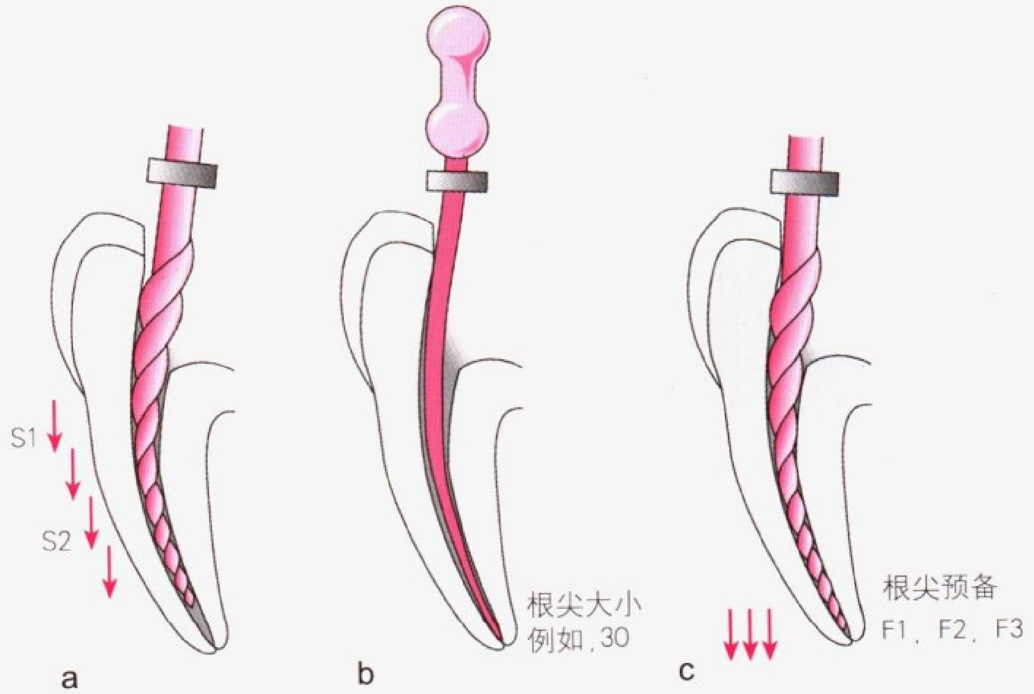


图 6-21　典型的 ProTaper 预备；a. 在 300rpm 的转速下先用 Shaper 1，然后用 Shaper 2 进行冠方下预备，直至根尖上方 1～2mm；b. 使用手用标准镍钛器械进行根尖测量；c. 根据根管的直径选择使用 Finisher 1，2 和 3 完成根尖预备

Fig 6-21　Typical ProTaper preparation, (a) Crown-down preparation with Shaper 1, then Shaper 2 at 300rpm. This continues until the apical 1-2mm is reached. (b) Apical gauging with standard NiTi instruments, (c) Completion of apical preparation with Finisher 1, 2, and 3 according to canal diameter.

与 0.06 锥度的 642 系统相比，渐进锥度系统减少了器械的数量，并在下列几方面的性能更优：

- 微力切割性
- 柔韧性
- 抗折性

无锥度的镍钛旋转系统

Lightspeed 是一套完全不同的器械，包括 22 个，从 20～100 号，并包含有半号器械，所有的器械均含有：

- 无切割能力的导向尖（图6-22）。
- 0.5～2mm 的短切割头。

Progressive tapers reduce the number of instruments compared with .06 and 642 systems and are claimed to optimise:

- light cutting
- flexibility
- fracture resistance.

Non-tapered NiTi Rotary Systems

A fundamentally different approach is presented by Lightspeed, with features including 22 instruments from size 20-100, with half sizes, all incorporating:

- non-cutting pilot tips (Fig 6-22)
- short cutting heads of 0.5-2mm

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图6-22 Lightspeed的特点是有一个狭窄的、柔韧性好的无锥度柄，短切割头和无切割能力的导向尖

Fig 6-22 Lightspeed, featuring a narrow, taperless, flexible shank, short cutting head and non-cutting pilot tip.

- 柔韧的、无切割能力的狭窄柄。
- 转速为750～2 000rpm。

预备应从根尖开始，因为无锥度的Lightspeed是惟一能够在初步开放根管前测量根尖直径的器械。

标准预备（图6-23）

- 将标准15号锉插入根管，测量工作长度（图6-23a）。如有必要可用G钻扩大根管口。
- 手工挑选合适的Lightspeed器械，使其插入根管后，能够达到稍短于工作长度的阻力位（图6-23b）。
- 使用此号器械进行旋转预备。器械进入根管时需轻柔，当遇到阻力时可以一点点切割牙本质。这样器械可以到达工作长度，此时可退出器械。
- 器械再增加半号进行机械预备，逐步推进直至工作长度。

- narrow, flexible, non-cutting shanks
- rotation at 750-2000rpm.

Preparation begins apically because taperless Lightspeed is uniquely able to gauge canal diameter before flaring.

Typical preparation (Fig 6-23)

- Negotiate canals with a standard size 15 file and determine working length (Fig 6-23a). Canal entrances can be flared with Gates if desired.
- Hand-fit Lightspeed instruments until one binds short of working length (Fig6-23b).
- Commence rotary preparation with the first binding instrument, sweeping gently into the canal and pecking to nibble dentine as resistance is met. Immediately the instrument reaches working length, sweep it from the canal.
- Continue through half sizes, advancing instruments with pecking motion to working length.

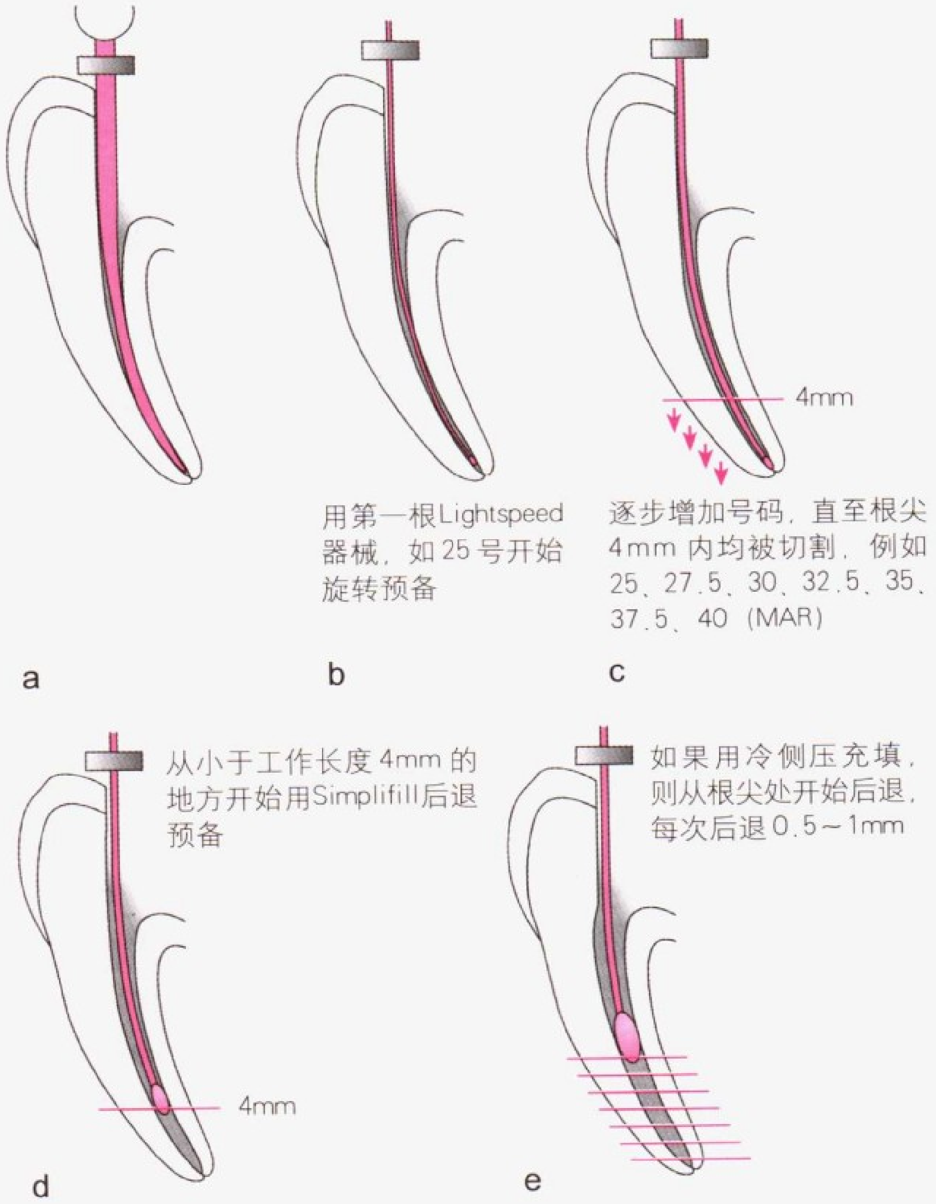


图 6-23　典型的Lightspeed预备。a. 使用标准15号锉确定工作长度。b. 手工挑选合适的器械，使其插入根管后，能够达到稍短于工作长度的阻力位。使用此号器械开始旋转预备，并逐渐增加半号进行预备。c. 连续预备，直到根尖上方4mm均可被预备。此时的号码就是主尖旋转。d. 如果使用Lightspeed Simplifill系统进行根管充填，可以从距根尖4mm处逐步后退预备冠部的根管。e. 如果进行冷材料侧压充填，此时需要采用传统的逐步后退法

Fig 6-23　Typical Lightspeed preparation. (a) Negotiate and determine working length with a standard size 15 file. (b) Hand-fit Lightspeed until an instrument binds short of working length. Commence rotary preparation with this instrument and increase through half-sizes. (c) Continue until the apical 4mm is being cut. This is the Master Apical Rotary. (d) Step back commences 4mm from working length for Lightspeed Simplifill obturation. (e) Traditional step back for cold lateral condensation.

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- 当器械进入距根尖4mm时遇到阻力，可用此号器械完成根尖的预备（图6-23c），以锉为主尖旋转（MAR）。此号码通常会比其他预备方法的大。
- 根管预备的大小取决于充填技术。
- 对于Lightspeed Simplifill的GP充填（图7-8）。根尖4mm内无需进一步扩大。从距根尖4mm处开始逐步后退，用2，3个器械来完成冠部的预备（图6-23d）。
- 对于冷侧压或热垂直加压充填，根管需要预备较多，从根尖处开始，选用合适的器械以0.5～1mm的间隔逐步后退进行预备（图6-23e）。
- 每使用3个器械后，应进行根管冲洗，在预备的最后只能用MAR，达到工作长度。

Lightspeed是柔韧性最好的镍钛系统，虽然外观比较脆弱，但实际上比较耐用。与其他方法相比，其根尖预备较大，因此根尖1/3更易清洁，保守的锥度也能保留更多的牙本质。

- When an instrument is reached which requires pecking motions during the apical 4mm of the canal, apical preparation is complete (Fig 6-23c). This is the Master Apical Rotary (MAR), and is usually larger than for other techniques.
- The amount of flare depends on obturation technique.
- For Lightspeed Simplifill sectional GP obturation (see Fig 7-8), a parallel 4mm apical preparation and little further enlargement are required. Step back commences 4mm from working length and is completed with just 2 or 3 more instruments which feel to be cutting (Fig 6-23d).
- For cold lateral or warm vertical condensation, more flare is needed and step back is at 0.5-lmm intervals from the apex using instruments which feel to be cutting at the desired level (Fig 6-23e).
- Irrigation is recommended every third instrument and recapitulation to the working length occurs only at the end of preparation with the MAR.

Lightspeed is the most flexible NiTi system and its fragile appearance belies its durability. Large apical preparations are claimed to clean the apical third better than other methods, and conservative tapers may preserve more dentine.

镍钛旋转系统的优缺点

优　点

- 镍钛旋转系统具有许多创新性的优点：
- 一致的、高质量的根管锥度（图 6-24）。
- 即使是对根尖区进行扩大，也可保持无可比拟的根管同心圆性。
- 预备过程简单、流畅、快速。
- 降低了医师的工作强度。
- 切割碎屑进入器械的凹槽，最大程度的减小了根管阻塞。
- 冲洗溶液更容易进入。

缺　点

- 需要购买电动马达和耗材。
- 预备时间的减少可能会影响次

The Pros and Cons of Rotary NiTi

Pros

- Rotary NiTi has been a revolution. Amongst its many advantages are:
- Consistent, high-quality canal tapers (Fig 6-24).
- Unsurpassed canal centring, even with greater apical enlargement.
- Simplified, streamlined, rapid preparation protocols.
- Reduced operator fatigue.
- Diminished risk of blockage as material is carried out on the flutes of the rotating instruments.
- Better access for irrigating solutions.

Cons

- Costs of start-up hardware and ongoing consumables.
- Reduced preparation times may limit



图 6-24　用各种镍钛系统进行连续的平滑锥度预备

Fig 6-24　Consistent, smooth tapers with a variety of NiTi systems.

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氯酸钠清洁根管的效果，但目前还没有定论。

- 器械的折断——如果进行了适当的训练和根管探查，器械使用方法合理，能及时更换，则极少发生折断。经常进行上述工作可以达到事半功倍的效果。

- 与其他器械一样，旋转器械并不能完全开放和清洁根管系统。和预备的同心圆性不锈钢器械一样，镍钛器械也无法到达椭圆形及弯曲根管的所有部位，其最好的预备结果就是同心圆性的扩大，所以仍会残留一些无法到达的区域（图6-2）。这些部位最好能在超声辅助下，使用次氯酸钠进行彻底冲洗清洁。

哪一种系统最好？

尽管资料多种多样，但目前还无法证实哪一种镍钛系统的安全性和临床结果等方面更好，因此新手应对不同的方法进行试验，找出适合自己的方法，同时应回顾所有病例，并时刻追踪最新文献。

the capacity of sodium hypochlo-rite to clean canals effectively, though the true impact of this is not known.

- Instrument fracture – a recognised but rare event with proper training, canal exploration, methodical application and disposal of instruments. It may be a small price to pay for an overall increase in quality.
- Rotary instruments, like any other, cannot fully open and clean root canal systems. Just as it is impossible to direct precurved, circumferentially filing instruments into all regions of an oval, curved canal, so NiTi rotaries cannot be steered. The best they can do is concentrically enlarge certain regions, leaving uninstrumented recesses (see Fig 6-2) which will always require thorough irrigation, ideally with sodium hypochlorite and the help of ultrasound.

Which System Is Best?

Marketing information is rife, but there is little evidence to suggest that any NiTi system out-performs others in important areas such as safety and clinical outcome. New NiTi rotary users should therefore sample a variety of techniques in the laboratory to discover which work best in their hands, and all should review their cases and keep a watchful eye on the emerging

literature.

单次／多次就诊的疑虑

对于单次／多次就诊治疗的优点现在还存在争议。镍钛旋转系统的运用加剧了这种争议。因为对大多数牙科医师而言，即使是用于治疗磨牙，一次完成治疗在技术上也是可行的。

根管所处状态的重要性：

- 无根尖牙周炎的牙齿几乎不含微生物。目前也一致认为，单次就诊治疗最大程度地保持了无感染的环境和根尖周的健康。
- 伴有牙周炎的牙齿含有大量的微生物，多次就诊是否会比单次就诊产生更好的治疗效果，不过目前仍有疑问。

对于两种方法，现在还无法给出明确的答案，但所采用的预备方法必须具有良好预后的理论依据以及实践上的可行性。根尖牙周炎是由微生物引起的，因此应尽可能消灭所有的微生物。根管内封药消毒有助于杀菌，但应告知患者可能出现轻微不适，需服止痛药，症状约 48h 后可消失。

The Single-/Multiple-visit Dilemma

Controversy surrounds the merits of single- or multiple-visit treatment. Rotary NiTi heightens the debate as single-visit treatment is now technically possible for most dentists, even in molars.

Canal status may be critical:

- Teeth without apical periodontitis contain few microorganisms, and there is consensus that single-visit treatment is best to preserve an infection-free environment and periapical health.
- Teeth with apical periodontitis contain large numbers of microorganisms, and the question remains whether a single episode of cleaning and shaping kills enough of them or whether an inter-appointment dressing and second-visit irrigation give a more predictable outcome.

A definitive answer cannot be given and the approach adopted must be a matter of outlook, philosophy and practice set-up. Microorganisms cause apical periodontitis, and we should do all we can to kill as many as possible. Intracanal medicaments can help in that process. Patients should always be discharged with advice to expect minor discomfort which may require simple analgesia for up to 48 hours.

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结　论

- 当前的手用和机用预备方法比较合理，可避免操作上的大部分错误，并可对主根管进行高质量的同心圆性扩大。
- 器械无法到达的区域和根管的二级分支需配合使用抗菌冲洗液和药物。
- 还无法证明哪一种预备方法最好。就诊的次数还存在争议。

Conclusions

- Contemporary manual and mechanical methods are rational because they eliminate most procedural errors and allow predictable, high-quality, concentric enlargement of major canals to the apical constriction.
- Uninstrumented recesses and secondary canal ramifications will always demand the use of antimicrobial irrigants and medicaments.
- There is little evidence to single out any particular technique as best, and debate continues on the desirability of single- or multiple-visit care.

拓展阅读
Further Reading

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第 7 章 保持愈合环境

Preserving the Healing Environment

目 的

介绍保持健康根管内环境的方法，即用根管充填材料和冠方保护来隔绝口腔菌群。

Aim

To describe methods of preserving a healthy intracanal environment by obliteration with root canal filling material and coronal protection from the oral flora.

要 点

通过学习本章，应了解根管充填和冠方封闭对于保持清洁、健康的髓腔环境所起的重要作用；并熟悉使用各种根充材料（包括冷牙胶、热熔牙胶和封闭剂）封闭根管的操作技术。

Outcome

After studying this chapter, readers should understand the role of the root filling and coronal seal in preserving a clean, health-compatible pulp space. They should also understand the practicalities of obturation with a variety of materials including cold and thermally softened gutta percha and sealer.

为什么要进行根管充填？

根管预备消除了根管中的微生物及其生存底物，为根尖周组织的健康提供了必备条件。许多人认为单纯的根管预备即可使病变愈合，并对根管充填的必要性提出了质疑（图1-8）。严格来讲，单独的根管预备并未给牙齿提供保持清洁与无菌的内环境。对于

Why Fill Root Canals?

Canal preparation eliminates microorganisms and substrate and provides the necessary conditions for periapical health. Many have witnessed substantial healing following preparation alone and questioned whether root fillings are needed (Fig 1-8). Strictly, they are not, provided the internal

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这一问题，牙周病医师可能会推荐对根管内进行定期的内部菌斑控制、冲洗以及装置缓释抗菌系统。然而，由于根管治疗后的牙齿必须进行修复，因此反复进入根管内来进行〝保持清洁治疗〞并不可行。所以在临床操作中，不进行根管充填很难保证根管系统的清洁。

environment of the tooth remains clean and microbe free. Faced with a similar challenge, a periodontist may recommend regular internal plaque control, irrigation and perhaps the installation of a sustained-release antimicrobial device. Regrettably, repeated entry for environment-preserving "maintenance therapy" is not possible in endodontics since root canal treated teeth must be restored. It is therefore difficult to imagine, in practical terms, how a clean canal system can be preserved without filling it.

根管充填的主要目的是阻止来自冠部、根尖部和侧方入口的液体和微生物进入根管，其作用为：

- 阻止来自口腔的新发感染。
- 限制和消灭根管预备后残留微生物进行繁殖所需的营养物质和空间。

为达到上述目标，冠方修复与根管充填同等重要，两者缺一不可。

The principal role of the filling is to provide a fluid and microbe-tight seal of all coronal, apical and lateral portals of exchange:

- preventing new infection from the oral cavity and
- imprisoning, denying nutrients and space to multiply for any organisms left after preparation.

The coronal restoration is as important as the root filling in achieving these goals; neither will deliver alone.

根管充填的时机

- 根管已尽可能地彻底清洁。
- 根管塑形完好，能获得理想的封闭效果。
- 医师有足够的时间来完成根管

When Should Root Canals Be Filled?

- When they have been cleaned as thoroughly as possible.
- When they have been shaped for optimal seal.
- When there is enough time to achieve

的良好封闭(所需时间取决于充填方法，一般不会很长)。

对需多次复诊的病例，完善根管预备的指征包括：

- 无疼痛。
- 窦道消失。

在单次及多次治疗中，根管必须尽可能保持干燥。

若根管中含有血液或血清则会导致：

- 根管封闭不全。
- 可为微生物提供丰富的营养和生存空间。

如何进行根管充填?

理想的根管封闭系统应具备以下特征：

- 良好的生物相容性。
- 良好的封闭性。
- 持久的抗菌性。
- 对机体无毒。

理想的根管封闭系统应能进入根管系统的各个分支、且不溢至外周，同时便于部分或完全去除。

虽然目前使用的各种方法均达不到上述理想化要求，但在临床上并非如此严格的操作才能获得预期的成功。实际上，只要对所有主根管进行预备，并使用无刺激性材料严密充填至根尖2mm内(图7-1)，便可获得良好的效果。

a quality seal (depending on the method, this may not be very long).

For those practising multiple-visit treatment, reassuring signs of adequate preparation include:

- the absence of pain
- the disappearance of sinus tracts.

In single- and multiple-visit treatment, it must be possible to dry the canal.

Incorporating blood or serum:

- compromises seal
- provides rich nutrients and growing-space for microorganisms.

How Should a Root Canal System Be Filled?

The ideal system would introduce a:

- perfectly biocompatible
- perfectly sealing
- permanently antimicrobial
- non-deteriorating

material into every ramification of the root canal system without it ever escaping into surrounding tissues. Partial and total removal would be similarly simple and complete.

It is reassuring that whilst current methods fall short of this ideal; such stringent performance is not needed for predictable clinical success. In fact, excellent outcomes can be expected if all major root canals are prepared and densely filled with bland ma-

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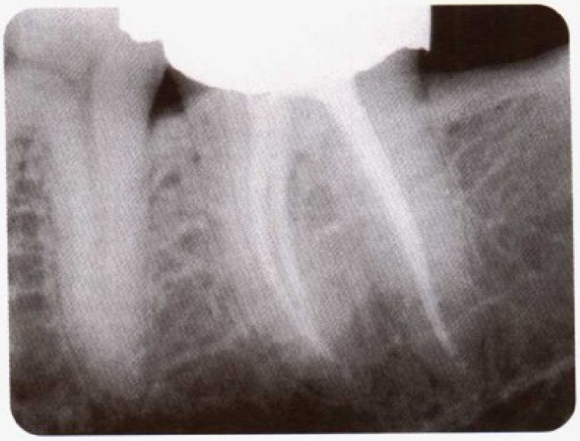


图7-1 此类根充虽不十分理想，但仍可保持根管系统清洁，获得临床上的成功
Fig 7-1 Not ideal, but a root filling likely to keep the canal system clean and win clinical success.

terials to within 2mm of root-end (Fig7-1).

目前根管充填大都使用冷牙胶或热牙胶加压充填，并配合使用具有流动性的封闭剂。

Currently, this almost universally involves cold or warm compaction of a rubber material (gutta percha) with a fluid sealer cement.

根充材料中各成分的作用

The Role of Filling Components

牙胶是充填根管的主要成分，其特点有：

- 价格便宜，品种繁多，易于操作。
- 性能稳定，无毒。
- 良好的生物相容性。
- 不支持微生物生长。
- 可加压，可溶解，可加热。
- 桩道预备和根管再治疗时易于去除。

但单纯使用牙胶无法获得良好的封闭效果，必须配合使用封闭剂。

封闭剂像密封圈一样，起封闭作用。在压力作用下，封闭剂可以流动，填塞不规则的间隙，并与根管壁紧密接触。封闭剂应具有以下特性：

Gutta percha provides the bulk of a root filling. It is:

- inexpensive, versatile and easy to handle
- stable and non-deteriorating
- adequately biocompatible
- non-supportive of microbial growth
- capable of adaptation with pressure, solvents and heat
- simple to remove for post-space and re-treatment.

However, it does not seal well on its own and must always be used with a sealer.

Sealer cement acts as a gasket and provides the seal. During compaction, it flows to fill irregularities and provides a tight interface with canal walls. Sealers may also:

- 在牙胶充填根管时起润滑作用。
- 有效抑制细菌生长。
- 促进根尖硬组织的修复。

推荐使用慢干型材料，原因在于：

- 即使在潮湿和高温环境中，也有足够的时间对牙胶加压。
- 在固化过程中可持续流动来补偿收缩力，防止因收缩导致材料与根管壁分离而破坏封闭。

然而，根管封闭剂（表 7-1）的相关临床性能我们知之甚少，还无法确认哪种材料的短期或长期临床效果更好。医师大多根据其操作是否简便以及个人喜好进行选择。

在根管充填时，尽量增加牙胶体积，同时尽量减少封闭剂体积，可实现两者性能的最优化（图 7-2）。通常可采用冷牙胶加压充填法或热熔牙胶充填法。

牙胶加封闭剂的冷侧压充填

1. 冷侧压充填

原则：多根牙胶尖挤压后，形成紧

- lubricate the glide-path of gutta percha into the canal
- actively suppress microbial growth
- promote hard-tissue repair at the root end.

Slow-setting materials are preferred which allow:

- time for adequate gutta percha compaction, even in the presence of humidity and heat
- continued flow during setting to counter shrinkage forces which might otherwise pull the material away from canal walls and break the seal.

Surprisingly little is known about the relative clinical performance of root canal sealers (Table 7-1), and no material has been convincingly shown to provide superior short- or long-term clinical outcomes. Selection is usually based on nothing more than ease of handling and personal preferencc.

The properties of gutta percha and sealer are generally held to be optimised by maximising the volume of rubber and minimising the volume of sealer (Fig 7-2). This can be achieved by cold compaction or after softening with heat.

Cold Compaction of Gutta Percha with Sealer

1. Cold lateral condensation

Principles: Multiple cones of gutta

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表 7-1 常用的慢干型根管封闭剂及特点

Table 7-1 Examples of commercially available slow-setting root canal sealers and some of their properties.

种 类	特 点	举 例
氧化锌丁香油粘固粉类	使用最为广泛。未固化前对组织有刺激性，但固化后可吸收、且性能稳定。成分中的丁香油酚具有抗菌能力	TubliSealer® extended working time (Kerr) Pulp Canal Sealer® extended working time (Kerr)
氢氧化钙类	良好的生物相容性和成骨性，但远期可能发生溶解	Apexit® (Ivoclar) Sealapex® (Kerr)
树脂基质类	在欧洲广泛应用，工作时间长，易于溶解去除。固化前有刺激性，若超充则吸收缓慢	AH Plus® (Dentsply)
玻璃离子类	据认为可改善封闭性，增加根管强度，但尚未证实。预封装会导致浪费。桩道预备和根管再治疗时难以去除	ReokoSeal® (Reoko)
硅树脂类	前期研究效果不错	Ketac Endo® (ESPE)

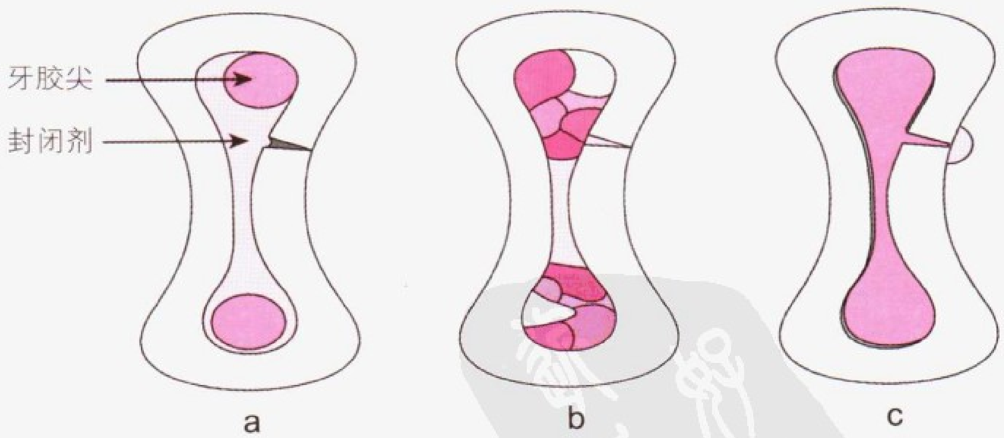


图 7-2 通过尽量增加牙胶体积同时减少封闭剂体积可实现两者性能的最优化：a. 单尖，大量封闭剂；b. 多尖冷侧压充填；c. 热熔牙胶充填

Fig 7-2 Optimising material properties by increasing the volume of rubber and reducing the volume of sealer: (a) Single cones in a large volume of sealer. (b) Multiple-point cold lateral condensation, (c) Thermoplastic obturation.

密核心，各牙胶尖之间及周围仅有薄层封闭剂（图 7-2b）。

percha compacted to form a dense core with thin interposing and surrounding films of sealer (Fig 7-2b).

加压时采用侧向加压器。侧压器表面光滑、呈锥形，工作原理类似楔子。垂直加压时可将牙胶挤向侧方（图 7-3），而并非像可引起根裂的杠杆一样将牙胶推向侧方。

Condensation is performed with a smooth, tapered "spreader" which acts like a wedge to squeeze the rubber laterally under vertical pressure (Fig 7-3), not by pushing it sideways like a root-splitting crow bar.

充填准备

所有的充填器械（包括侧压器和垂直充填器械）都应在预备好的根管内预试，以确保其到达所需的工作水平。理想的侧压器应能到达根尖，贯穿全长，以便于将充填材料压向根尖基点。

Preparing to fill

All condensing tools (spreaders and pluggers) should be tried in the prepared canal to make sure they will be able to work at the required level. A correct spreader should pass to the root terminus if it is to compact the filling into the apical seat and throughout its length.

选用标准化还是非标准化的侧向加压器？

这只是个人喜好问题。与0.02锥

ISO or non-ISO spreaders?

This is a matter of personal preference.

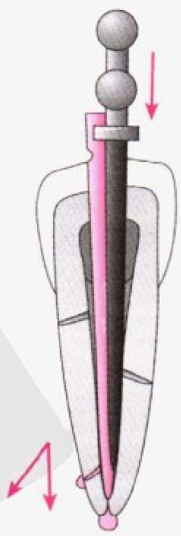


图7-3 冷侧压充填时，楔状侧压器的轴向作用可产生侧向压力。锥度越大，侧向压力越大。若侧压器尖端较平而非较尖，经常会使垂直向的压力增大

Fig 7-3 Cold lateral condensation generates lateral force by axial loading of a wedge-like spreader. The greater its taper, the greater the lateral component of force. There is always a vertical component of condensation which is increased if the spreader has a flat, rather than pointed tip.

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度的标准化器械相比，大锥度、非标准型侧压器（如medium-fine，fine-medium）可产生较大的侧向力，但不应为了适应器械而去除过多的牙本质。

Highly tapered, non-ISO spreaders (e.g. medium-fine, fine-medium) generate greater lateral force than .02 tapered ISO instruments, but more dentine should not be removed to accommodate them.

选用不锈钢或镍钛器械?

镍钛侧压器尤其适用于弯曲根管的充填，它可进入得更深，且对根管壁的压力较小。

Stainless steel or NiTi?

NiTi spreaders are especially useful in curved canals, penetrating deeper and placing less stress on canal walls.

副尖的选择

将侧压器从根管内取出后，留下相应大小和锥度的空隙。所选择的副尖应与其匹配或略窄，以到达空隙的最底部，避免残留的空气占据空间。

Accessory cone selection

When a spreader is removed from the canal, it leaves a space of its own size and taper. Accessory cones should match or be slightly narrower than the spreader so they will bottom-out in the spreader track and avoid air voids.

主尖试合

标准化和非标准化牙胶尖均可与预备后的根尖部相适合。标准化牙胶尖的大小通常与主尖锉相匹配，但应注意的是这种标准化并没有想像中的那样精确，位置的适合要比型号的匹配更为重要。非标准的medium-fine或fine-medium牙胶尖适用于大多数常规预备的根管，它更易通过弯曲根管，且在根尖止点不理想时，不易穿出根尖孔。而标准化牙胶尖在弯曲根管中有时会发生卷曲。

Master cone fit

ISO or non-ISO cones can be fitted to the apical preparation. ISO cones usually size match the master apical file, but it should be noted that standardisation is not always as accurate as we would wish. Position of fit is more important than nominal size match. Non-ISO medium-fine or fine-medium cones are suitable for most conventionally prepared canals. They may traverse curved canals better than ISO cones which can sometimes buckle, and have less tendency to slide through the apex if apical resistance form is not ideal.

主尖尖端的直径可通过已商品化的锥度测量尺和锐利的手术刀达到标准化（图 7-4）。在湿润的根管中试合主尖时，湿润的液体可起到与根管封闭剂同样的润滑效果。若所选侧压器合适，则主尖应位于距根尖0.5mm以内。

主尖过短的原因可能包括：

- 根尖阻塞。
- 尖端大小不适合。

由根管预备时切割下来的碎屑引起根尖阻塞时，需进行根管冲洗，并采用平衡力法重复根尖区预备。在退出前顺时针旋转 1/4 圈，使根尖的碎屑嵌入扩孔锉凹槽，达到根尖区的清洁。由于台阶导致的根尖阻塞，充填需小心操作，以弥补管壁的缺陷；或使用较弯曲的大锥度手用器械锉平台阶。

若尖端大小不适合，可从同一型号中另选一根进行试合，或重新修整

Tip diameter can be customised with a commercially available gauge and sharp scalpel (Fig 7-4). Master cones are tried in irrigant-moistened canals to lubricate their path in the same way as the sealer will. If a well-fitting spreader is available, the master cone should fit to within 0.5mm of the apical terminus.

Short master cones may be due to

- apical obstruction
- tip-size incompatibility.

Apical obstruction with cutting debris is removed by irrigating and repeating the apical preparation with Balanced-Force motion, finishing with a quarter-clockwise turn before withdrawal to load the apical flutes of the file with debris "apical clearing". Apical obstructions due to ledging usually require gentle canal filing to remove wall defects, or employing an over-curved GT hand file to bypass and plane away irregularities.

Tip size incompatibility is often overcome by trying another cone from the same

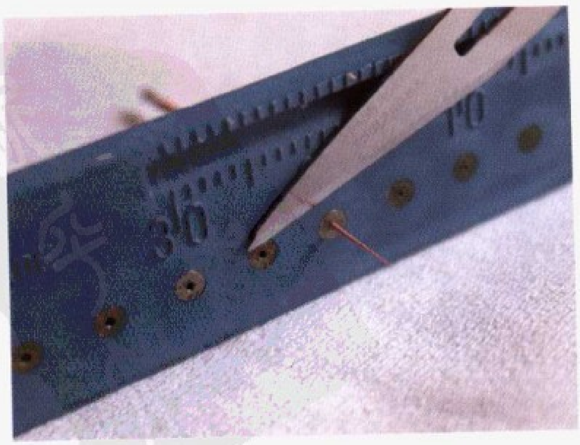


图7-4　用锥度测量尺和锐利的手术刀使主牙胶尖尖端的直径达到标准化

Fig 7-4　Customising gutta percha cone tip diameter with a gauge (Maille-fer/Dentsply) and scalpel.

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一根非标准化牙胶尖，使其尖端缩小。主尖过长通常由于根尖止点未有效形成所致，工作长度不准确或在牙根末端使用顺时针旋转扩锉，均可导致根尖止点形成不足。此时应缩减工作长度并重新确定，或者使用修整后的非标准型牙胶尖进行充填，此类牙胶尖加压后不容易超充。

pack, or re-trimming another non-ISO cone to a smaller tip size. Long master cones usually occur because of inadequate apical resistance form. This is usually a function of inaccurate working length determination, or of employing a clockwise-rotating file motion at root-end. The stop should be re-defined at a shorter length, or a non-ISO cone trimmed and fitted which will have less risk of compaction beyond root-end.

根管干燥

根管最后干燥时应首先采用冲洗针筒进行回吸，然后用纸尖吸干，有时可选用无水乙醇进行最后的冲洗，以达到干燥的目的。

Drying the canal

Final drying is done by aspiration with the irrigation needle and syringe, and wicking remaining moisture with paper points. Some finish the drying process with a final flush of absolute alcohol.

封闭剂

按说明书调好封闭剂，并准备副尖。

Sealer

Sealer can now be mixed in accordance with the manufacturer's instructions and accessory cones arranged ready for use.

充填过程（图 7-5）

封闭剂的使用

封闭剂需涂满整个根管壁，最常用的方法有：

- 使用机用螺旋糊剂输送器涂满根管
- 使用扩孔锉进行超声涂布

也可使用小号手用锉将封闭剂逐渐送入，这种方法最为常用，但效果

The filling process (Fig 7-5)

Sealer application

Sealer should coat all walls of the canal. This is most consistently achieved by:

- filling the canal with a lentulospiral paste filler
- insertion on a file before ultrasonic activation.

Incremental addition with a small hand file, inserted and turned anticlockwise dur-

最差。

在加压过程中，大部分多余的封闭剂会从冠方溢出，少量封闭剂可能会从根尖孔或侧方开口溢出。

ing advance into the canal, is the commonest but least effective method.

Most of the excess sealer will displace coronally during condensation, though small amounts may find themselves extruded through apical or lateral portals of exit.

主尖的插入（图 7-5a）

在主尖表面涂布薄层封闭剂，采用上下缓慢插入根管，并确认抵达根尖部分。若发生根管融合，各根管内应顺序插入主尖。

Master cone insertion (Fig 7-5a)

A lightly coated master cone is now slowly advanced with slight up-down pumping motion and firmly seated in the apical part of the canal. If canals are confluent, master cones should be inserted into both consecutively.

侧压器的插入（图 7-5b）

以1～3kg的垂直向压力将选好的侧压器插入根管深部。牙胶尖在根管内需数秒钟才会发生形变，因此侧压器应在原位保持至少10s，而后左右旋转退出。利用超声或回旋手机增能的侧压器加热牙胶，增强其流动性。

Spreader insertion (Fig 7-5b)

The measured spreader is then inserted deep with 1-3 Kg vertical finger pressure. Gutta percha requires several seconds to deform at canal temperature, and the spreader is held in place for at least ten seconds before watch-winding rotation to free it before removal. Energising the spreader with ultrasound or a reciprocating handpiece can warm and assist flow of the gutta percha.

副尖的插入和充填的完成（图 7-5c）

副尖表面涂薄层封闭剂，在取出侧压器后立即插入，达到侧压器所在的位置。

Accessory cone insertion and build-up of the filling (Fig 7-5c)

Immediately on removing the spreader, an accessory cone, lightly coated in sealer, is slid to the base of the spreader track.

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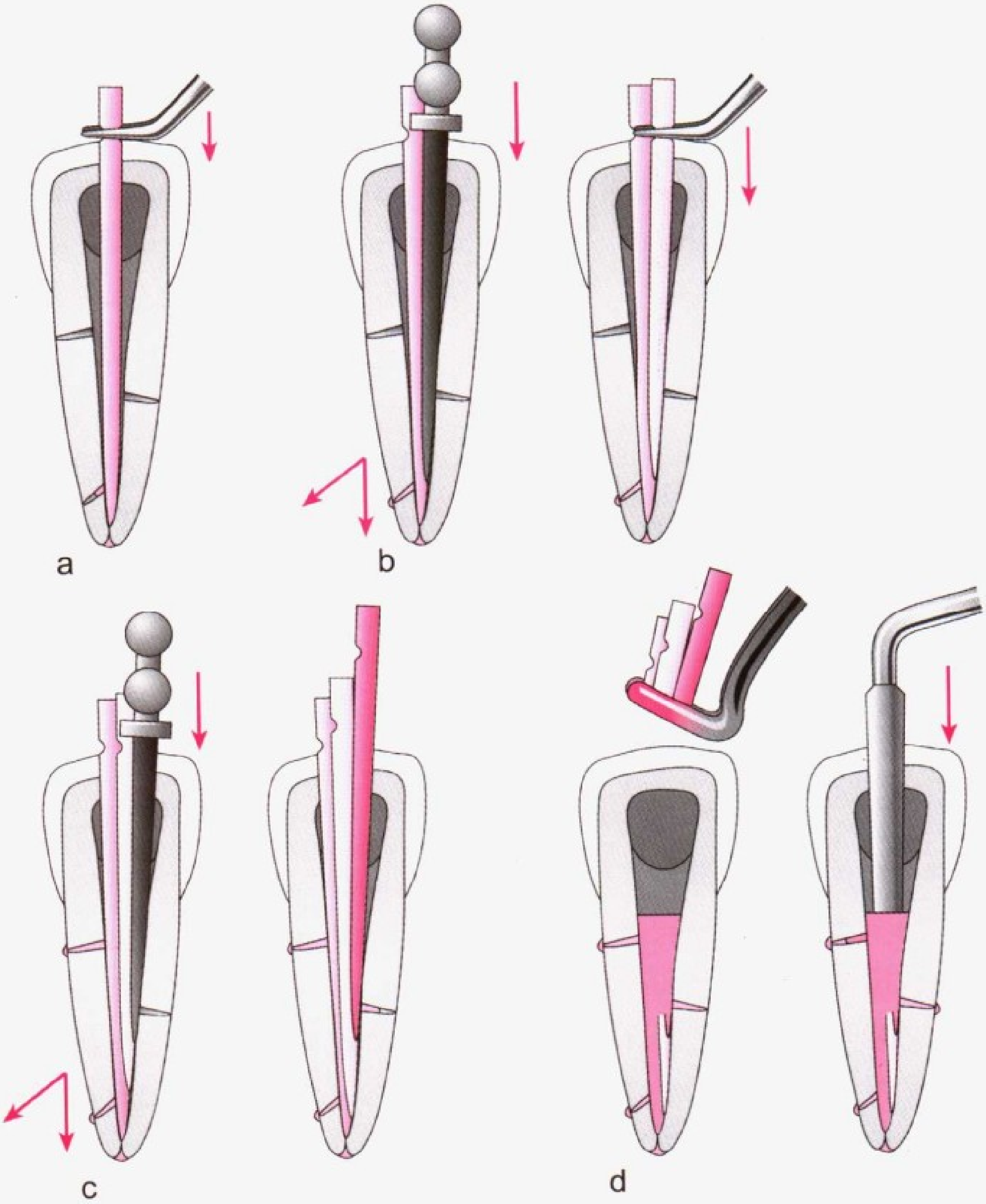


图 7-5 冷侧压充填。a. 将涂有封闭剂的主尖轻轻送入根管直至根尖基点；b. 使用侧压器在 1～3kg 的压力下垂直加压，并保持 10s，退出侧压器后加入副尖；c. 反复使用侧压器侧压，并在侧压器退出后用副尖填满余留间隙，直至侧压器进入根管内不足 2～3mm；d. 加热切断。热量可传至牙胶深部 5mm，因此可进行加压以使充填更为完善，并为修复预留空间

Fig 7-5 Cold lateral condensation. (a) Sliding the master cone home lightly coated with sealer, (b) Spreader application, loaded vertically with l-3Kg force. The spreader remains in place for ten seconds before watch-winding, withdrawal and insertion of an accessory cone, (c) Progressive application and build-up as the spreader walks out of the canal. Accessory cones should slide to length and bottom-out in the spreader track. Packing continues until the spreader can reach no more than 2-3mm into the canal, (d) Severing deep with heat. Heat transmits up to 5mm through the mass of gutta percha and can be condensed to improve the filhng and make space for the restoration.

再次将侧压器插入，重复上述过程。当侧压器逐渐退出锥形根管时，其每次的压力仍主要集中于尖部。反复侧压并加入副尖，直至插入根管深度不足2～3mm（即超过釉牙骨质界），无需达到根管口表面。

The spreader is inserted deep once again, and the process continued. Compression is taking place predominantly at the tip of the spreader as it walks progressively out of the tapered canal. Condensation and insertion of gutta percha continues until the spreader will reach no deeper than 2-3mm into the canal (i.e. beyond the cementum/enameljunction). There is no benefit in continuing to the cavosurface of the access cavity.

辅助加热（图 7-5d）

冷侧压充填的方法不仅如此，通常还包括对材料进行辅助加热，其热源主要有：

- 加热型携热器。
- 电子加热仪。

牙胶尖切断后，温热的牙胶尖紧密贴合于根管内，再次使用垂直加压器可使充填物与管壁间更为密合，以巩固充填效果。牙胶的软化可延伸至牙胶下 5mm，因此，这样的垂直加压可对根管系统深部产生影响。

Severing with heat (Fig 7-5d)

Cold lateral condensation is never just that. Material is always severed deep with heat from a:

- red-hot heat carrier
- battery-operated "touch 'n' heat" instrument.

After cutting off, the warmed mass of gutta percha is firmly condensed with a plugger to improve adaptation and consolidate the fill. Softening extends up to 5mm into a mass of warmed gutta percha, and vertical condensation of this sort can exert an influence deep into the canal system.

操作基础

单独冷侧压充填可作为独立的根充，或作为以下操作的基础操作：

- 使用可以更深入的热源，持续加热并垂直加压，以使充填更为严密。

Foundations

Cold lateral condensation can stand alone, or form the foundation for:

- continued warm vertical condensation, with deeper waves of heating and packing to improve density and adap-

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tation

• 热机械充填，即使用旋转型的加压器，通过摩擦产热来软化充填材料（图 7-6）。

• thermomechanical compaction, where a rotary condenser creates frictional heat and carries in softened material (Fig 7-6).

为临时充填或永久充填留出的空间应不小于 3mm。

At least 3mm of space should be available for a sealing provisional or permanent restoration.

金标准

冷侧压充填仍然是用来评价其他各种充填技术的金标准，因此采用冷侧压技术无可厚非。如果能对此技术加以补充则更好，但目前还不能证明改进后的方法比冷侧压法的远期临床效果更好。

The gold standard

Cold lateral condensation remains the gold standard obturation technique against which all others should be evaluated. Those who practise cold lateral condensation well have nothing to be ashamed of. If they wish to supplement their technique, that is well and good, but there is no method shown to provide better long-term clinical outcomes at this time.

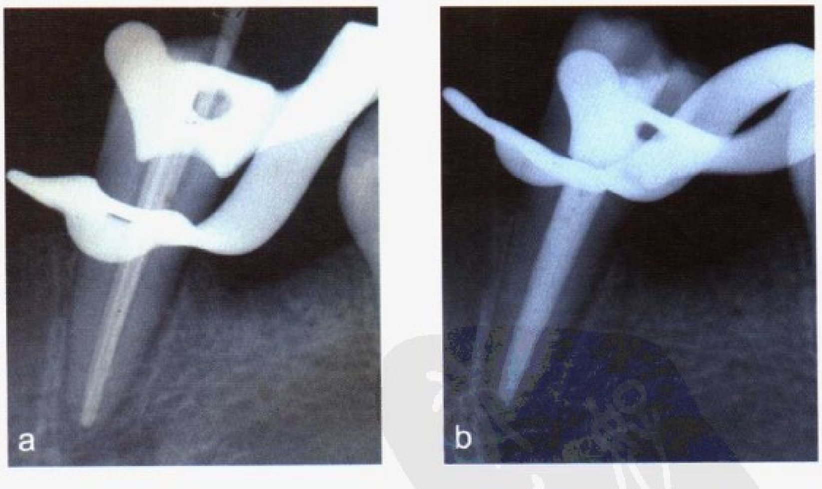


图 7-6 热机械充填。a.使用冷侧压法对一较宽的根管进行部分充填；b. 对同一根管进行 5s 的热机械加压。将根管外多余的材料加热，并进行机械加压

Fig 7-6 Thermomechanical compaction. (a) A wide canal partially filled by cold lateral condensation, (b) The same canal after five seconds of thermomechanical compaction. Excess material outside the canal was warmed and fed-in by the mechanical compactor.

2. Lightspeed Simplifill(图 7-7)

在使用普通器械时，由于弯曲根管无法预备成同心圆状，因此单核心充填技术没有什么优势。同样，在根管充填时也应避免使用大量的封闭剂，其原因在于：

- 封闭剂在根管内的长度难以控制。
- 密度不均匀。
- 封闭剂的固化收缩可能会破坏与管壁的密合与封闭。

Simplifill 技术的特点在于用封闭剂回填之前，选择了与Lightspeed预备后根尖部4mm内的形态相匹配的根尖牙胶来封闭根尖孔。

试　尖

选择大小合适的 Simplifill 根尖牙胶在湿润的根管内试尖（图 7-8a）。当进入预备好的根尖区时应感到有轻微阻力，此时不应将其完全就位，而应不加旋转将其取出并干燥。

2. *Lightspeed Simplifill (Fig 7-7)*

Single-cone obturation techniques fell out of favour when it was realised that curved canals could not be prepared to a circular cross-section with conventional instruments. Equally, large volumes of sealer have been shunned because of:

- difficult length control
- erratic density
- setting contraction in large volumes of material which may disrupt close wall adaptation and seal.

Simplifill challenges convention by fitting a parallel section of gutta percha into a circular apical 4mm Lightspeed preparation before backfilling with sealer.

Try-in

A size-matched Simplifill apical plug is tried in the moist canal (Fig 7-8a). Slight resistance should be felt as it advances into the apical preparation and it should not be finally driven home if apical resistance is

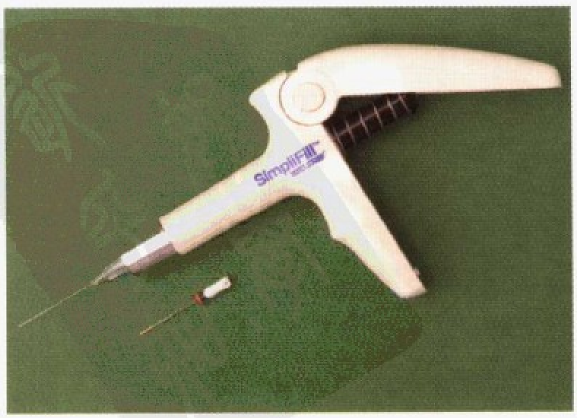


图7-7 Lightspeed Simplifill的枪头和回填注射器

Fig 7-7 Lightspeed Simplifill apical tip and backfill syringe.

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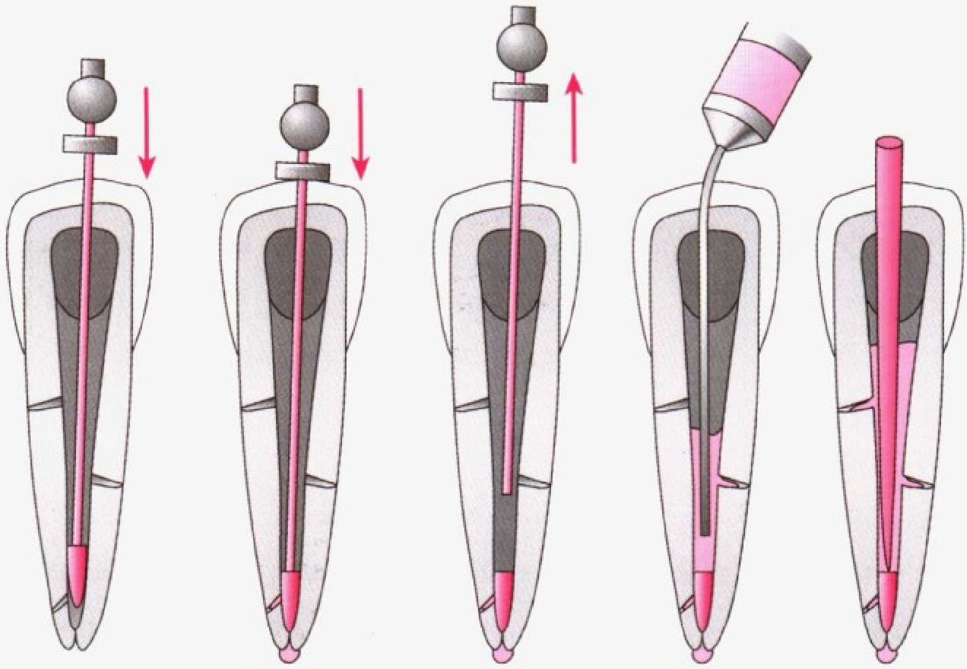




图 7-8 Lightspeed Simplifill 技术。a. 在湿润的根管内进行尖端试合，应能感到阻力，但不可将其完全就位；b. 根尖牙胶尖涂封闭剂后完全就位于根尖；c. 移去手柄，留下密合的根尖牙胶；d. 回填封闭剂。可在中间插入牙胶尖，作为根管再治疗或桩道预备的指示剂；e. 从技术角度上讲结果比较满意，但与其他许多方法一样，长期效果尚不明确

Fig 7-8 Lightspeed Simplifill technique, (a) Trying an apical tip in an irrigant-mois-tened canal. It should meet resistance but should not be fully seated, (b) Seating the apical tip fully in a sealer-coated canal, (c) Removal of the carrier, leaving a tightly fitting apical plug of gutta percha. (d) Backfill with sealer. Gutta percha can be added if desired to provide a path for retreatment or post-preparation.(e)Technically satisfactory outcome. In common with many techniques, long-term outcomes are not known.

根尖牙胶就位

干燥后，根尖牙胶表面涂布封闭剂（推荐使用 AHPlus 或 Ketac Endo），

felt. The device is removed without twisting and dried.

Seating the apical plug

After drying and sealer application (AHPlus or Ketac Endo are recommended),

轻轻加压将其送入根管至工作长度（图 7-8b）。将金属手柄逆时针旋转松开，使牙胶尖堵塞预备好的根尖部分（图 7-8c）。

the tip is slid with some pressure to full working length (Fig 7-8b). The metal carrier is unscrewed anticlockwise, leaving the apical preparation "corked" with a gutta percha plug (Fig 7-8c).

回　填

用27号针头和输送枪从根尖牙胶处回填封闭剂，并插入单根牙胶尖，作为日后根管再治疗和桩道预备时的指示剂（图 7-8d）。另外，也可使用侧压充填法严密封闭剩余的空间。

Backfill

Sealer delivered -with a 27 gauge needle and applicator gun to backfill from the apical plug, and a single gutta percha cone inserted to provide a ready pathway for retreatment or post space preparation (Fig 7-8d). Alternatively, the space can be compacted more densely with laterally condensed gutta percha.

同时应该看到，这项简单的充填系统也与其他临床技术一样，充分利用了镍钛器械预备的同心圆性（图 7-8e）。

It remains to be seen if this simple system which exploits the concentricity of NiTi preparation performs as well as other techniques clinically (Fig 7-8e). There is no reason why it should not.

热牙胶技术

解剖结构的复杂性使根管系统在充填时几乎无法达到无菌。因此通过加热软化牙胶来增加流动性，从而将细菌局限在根管分支内十分重要。由此也证明了根管内存在许多重要的二级解剖结构（图 7-9）。这种结构可能对医师十分重要，原因如下：

- 使医师感到对根管系统的充填

Warm Gutta Percha Techniques

Anatomical complexity means that few canal systems are completely free of bacteria at the time of obturation. It is therefore rational to work harder to imprison bacteria remaining in canal ramifications by thermally softening gutta percha to improve its flow. As a result, more secondary anatomy can be demonstrated (Fig 7-9), which may be important to dentists because:

- they may feel they are filling canal sys-

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图7-9 较好地显示了二级解剖结构（感谢G V Seccombe供图）
Fig 7-9 A pleasing display of secondary anatomy, but does it matter? (Courtesy G V Seccombe).

更为彻底。

- 术后的X线片更加完美。

- 术后X线片的复杂影像揭示了此技术比仅对主根管进行严密充填的方法更加成熟。

目前还不清楚根管的二级解剖结构对最终的愈合有何影响，但上述各项有利于医师保持工作兴趣，并竭力为患者服务。

tems more completely

- the postoperative radiograph may reveal exciting surprises to enliven their practice - “the thrill of the fill”
- the achievement of a complex postoperative “look” may imply greater mastery of technique than cases in which just the main canals are densely filled.

There is currently little evidence that demonstrating secondary anatomy has any real impact on healing outcome, but all the points listed are laudable enough in maintaining interest and working to do our best for patients.

1. 加热垂直充填技术——多波

传统的Schilder技术需要反复加热和加压。

- 进行大锥度预备，形成根尖限制区而非限制点。

1. Warm vertical condensation - multiple wave

The traditional Schilder technique involves repeated episodes of heating and compaction.

- The preparation usually has a wide taper, with an apical control zone,

- 尖端直径逐渐减小的充填器至少需要三根（图 7-10）。使用前均应在根管内试用以确定其进入根管的深度。最细器械的进入深度应小于工作长度5mm（图7-11a）。
- 完善的充填需采用与预备锥度相匹配的牙胶尖（如0.06锥度），并将其修整至略小于工作长度0.5mm。有时可通过观察干燥牙胶尖在预备后的根管内是否有阻力，来对充填长度进行微调。在融合根管中，应首先在最直的根管内插牙胶尖至根尖处，然后在另一根管内再插入一根牙胶尖至根管融合处（图 7-11b）。
- 根管干燥后，在内壁涂布薄层封闭剂，并将主尖就位至工作长度（图 7-11b）。在融合根管中，其他牙胶尖也应同时就位。在垂直压力作用下封闭剂可能会溢出

rather than a stop.

- At least three pluggers of decreasing tip diameter are needed (Fig 7-10). They should be tried in the canal to confirm depth of penetration. The smallest should extend no closer than 5mm from working length (Fig 7-11a).
- Cone fit is usually with a cone of similar taper to the preparation (e. g., .06 taper), trimmed to give slight tug-back 0.5mm short of working length. Fine-tuning of filling length is sometimes achieved by noting a constant drying point in a preparation without a stop. In canals which are confluent, the straightest path should be used to cone-fit the apex. The other canal can then be cone-fit to the point of confluence (Fig 7-11b).
- After drying and lightly coating the canal with sealer, the master cone is seated to length (Fig 7-11b). In confluent canals, the other cone is seated at the same time. Hydraulic pressure

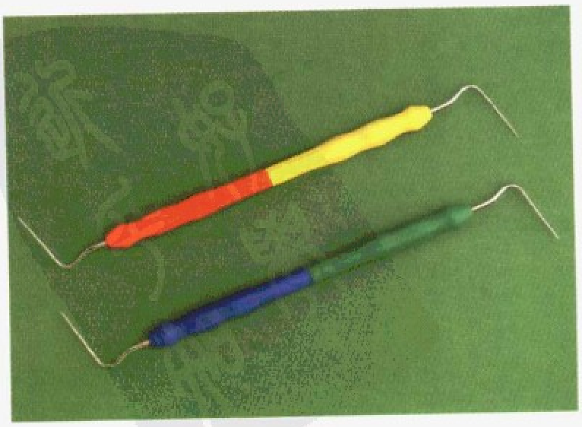


图 7-10　热垂直充填所使用的充填器（Maillefer/Dentsply）

Fig 7-10 Pluggers for warm vertical condensation (Maillefer/ Dentsply).

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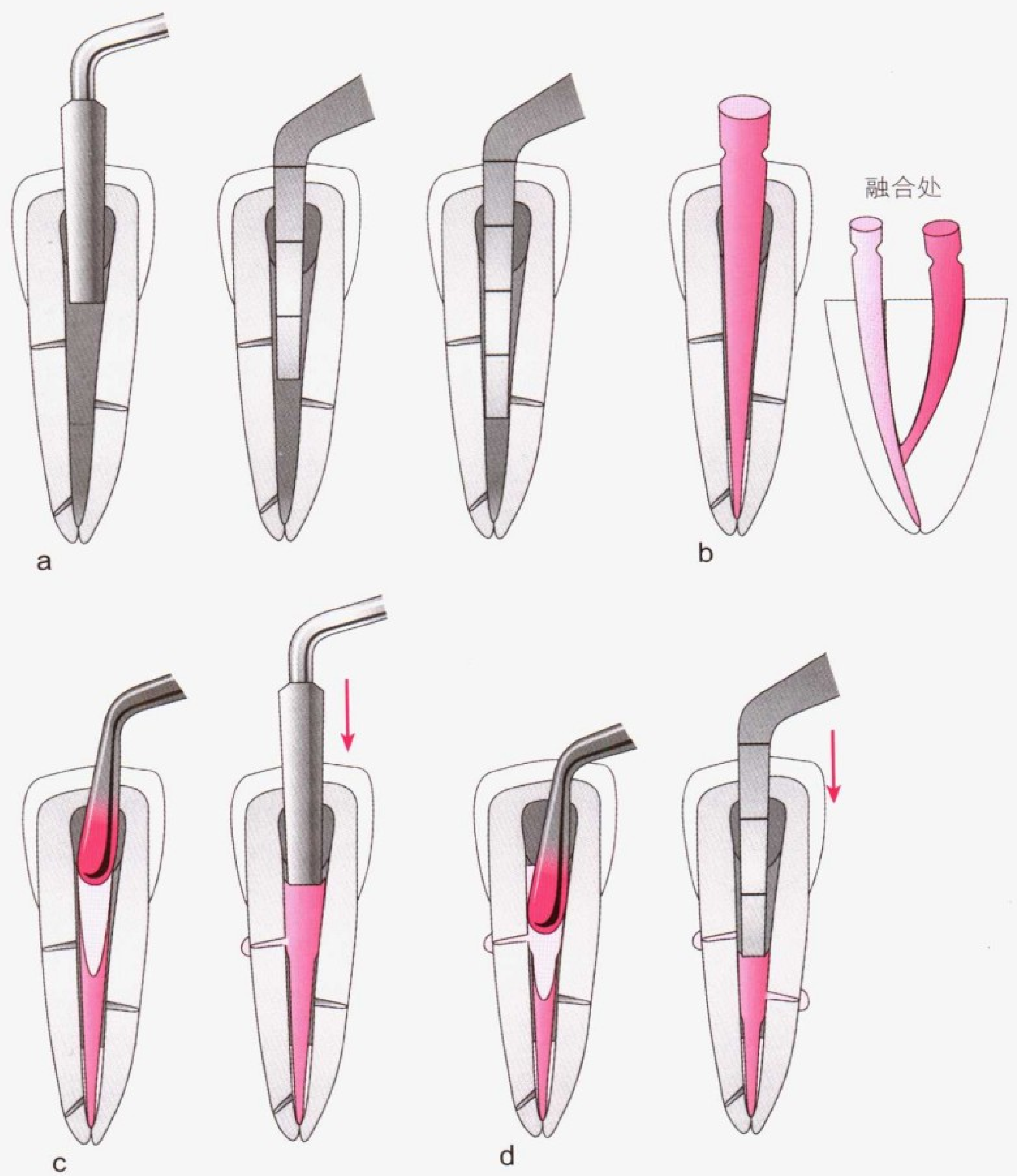
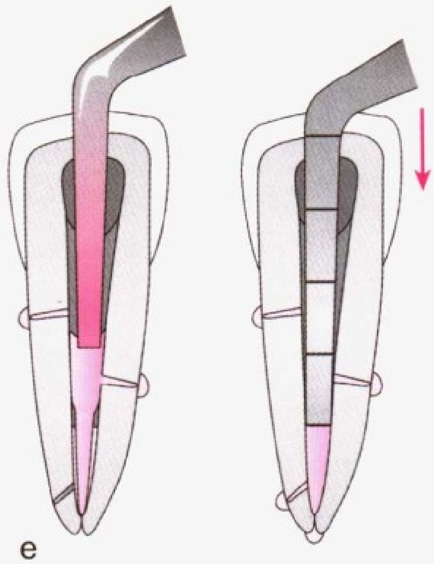
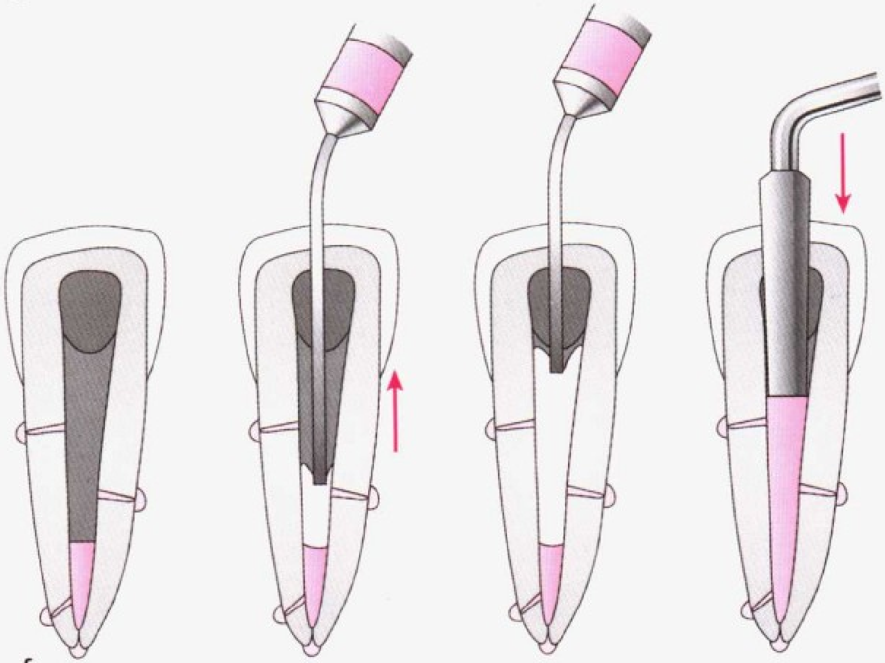


图7-11 多波垂直充填。a. 充填器试合，最小的充填器应距根尖5mm处；b. 主尖就位。融合根管中，应首先在最直的根管内插牙胶尖至根尖处，然后在另一根管内再插入一根牙胶尖至根管融合处；c. 第一波加热和加压；d. 第二波加热和加压

Fig 7-11 Multiple wave vertical condensation. (a) Trying in pluggers. The smallest should reach 5mm from working length. (b) Seating the master cones. With confluent canals, the straightest path is used for the apical cone, and the second cone trimmed and inserted to the confluence. (c) First wave of heating and compaction. (d) Second wave of heating and compaction.



e



f

图 7-11　e. 第三波和最后一次加热和加压，封闭根尖；f. 此时可进行桩道预备或用回填枪进行回填

Fig7-ll　(e) Third and final wave of heating and compaction seals the apex. (f) Post space is now available, or the canal can be back-filled with a gun system.

根尖，因此应避免使用过量封闭剂。

- 可用携热器、本生灯或"无触热"仪进行加热。将根管口下方的牙

during vertical compaction can dramatically "shoot" sealer through the apex. Excess should be avoided.

- Heat can be supplied by a heat-carrier, warmed red-hot over a bunsen burner,

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胶尖加热，用第一根冷充填器加压（图7-11c）。注意充填器勿进入过深，并避免与管壁直接接触，以免产生楔力。

- 第二波和随后几次加热时去除根管表层软化的牙胶，同时充填器加压时进入根管内更深、更狭窄的位置（图7-11d，e）。连续进行加热、移除及加压操作，直至距根尖5～7mm处。

- 此时向下加压充填完成，根尖处已被完全适合的材料阻塞（图7-11e）。如果加热止于根尖5mm外，则根尖区的锥度预备能有效地阻止牙胶尖超出根尖孔。这种方法极有可能将材料挤入所有的二级解剖结构中，此时若不需桩道预备则可回填剩余间隙。

- 可使用注射式牙胶枪系统进行快速回填。在枪内装满封闭剂后，将注射针插入根管，先在根管内停留数秒，预热根管及其表面的牙胶尖，而后将新的牙胶逐

or with a touch 'n' heat. Gutta percha is severed below canal entrance level and pressure applied with the first cold plugger (Fig 7-11c). Care should be taken not to drive the plugger too deep and make direct wall contact which can generate damaging wedge-like forces.

- Second and successive waves of heating remove bites of softened gutta percha from the canal (there is no need to be alarmed), whilst pluggers advance deeper into the apically narrowing preparation (Fig 7-11 d,e). The process of heating/removal and compaction continues until the apical 5-7mm are reached.

- Downpack is now complete and the apex "corked" with well-adapted material (Fig 7-1 le). The tapering apical preparation should have prevented movement of gutta percha beyond the apex provided that heat was kept out of the apical 5mm. It is expected that material will have been forced into all secondary anatomy during the downpack, and unless a post is planned, the empty space should now be backfilled.

- Back-fill is achieved most quickly with an injection-moulded gutta percha gun system. After adding more sealer, the needle is advanced and held for a few seconds to warm the canal and surface

步注入根管内，快速充填死腔（图 7-11f）。此时，每充填 3～4mm 需再次使用冷充填器加压一次，来减少收缩。或者将 3～4mm 长并有一定锥度的牙胶蘸少量封闭剂后插入根管内，如上所述加热和加压，逐渐填满根管。

of the apical plug before passively injecting, welding the new gutta percha to the apical increment and rapidly filling the dead space (Fig7-11f). Cold pluggers are again used to counteract shrinkage in each 3-4mm length of material deposited. Alternatively, 3-4mm lengths of tapered gutta percha can be added to the canal with a little sealer, heated as previously and packed apically, progressively walking out of the canal.

这种分段式技术操作费时，技术要求高，比昂贵的枪式技术更不实用。

This sectional technique is more time-consuming, technique-sensitive and prone to voids than the more expensive gun method.

2. 加热垂直充填技术——单波

热垂直充填由 Buchanan 系统（System B®）改进而来，并配备了一系列枪头（图 7-12），其特点为：

- 开启后可迅速加热。
- 停止激活后可迅速冷却。

这意味着同一枪头既可用于加热又可进行充填，大大减少了所需器械的数量。

- 根管预备和试尖与多波技术的要求一致。

2. *Warm vertical condensation – single wave*

Warm vertical condensation has been transformed by the Buchanan System (System B®) heat source with its series of tips (Fig 7-12) which:

- heat instantly from the tip when activated
- cool almost as rapidly on de-activation.

This means that the same tip can be used as both heat source and cold plugger, largely eliminating the need for multiple applications of heat and compaction.

- Canal preparation and cone fit is exactly as described for the multiple wave technique.

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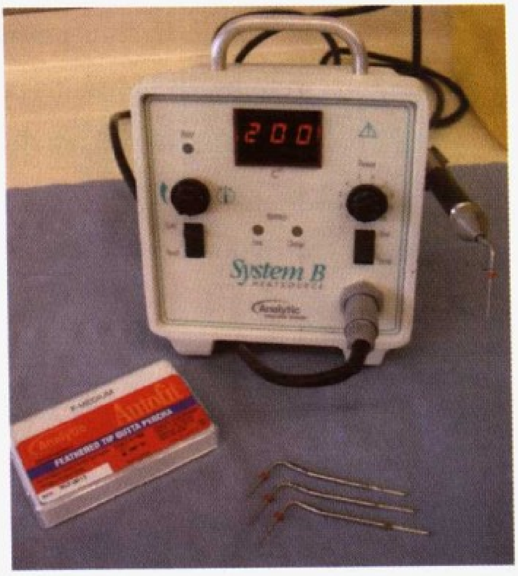


图7-12 用途广泛的System B® 加热系统，配备多根加热/充填枪头

Fig 7-12 The versatile System B® heat source with its variety of heater/plugger tips.

• 为每一根管选择一个加热/充填枪头，要求进入根管后，其尖端距根尖5～7mm，此点为结合点（图7-13a）。这些枪头由软金属制成，易于弯曲。预先用一根常规的不锈钢充填器或Buchanan镍钛充填器进行试合也十分必要。

• 按照工作长度的要求，在根管壁和主尖的表面涂一薄层封闭剂。

• System B®加热器温度设置为200℃时，向下加压可使液体流动。加热2s，枪头就可以穿过软化的充填材料，到达距结合点2mm处（图7-13b）。此时停止加热并持续加压，可使冷却的枪头到达结合点（图7-13c）。压力保持10～15s，直至根尖方向的充填物冷却及收缩。

• One heater/plugger tip is selected for each canal which will extend deep and bind against the walls approximately 5-7mm from working length (Fig 7-13a). They are made from soft metal and will bend into curves. It is also wise to pre-fit a regular stainless steel or Buchanan NiTi plugger should this become necessary.

• Sealer is lightly coated on the walls and master cone, which is seated to length.

• Downpack is in one fluid movement with the System B® heat source set to 200℃. The warm tip takes two seconds to advance through softened material to approximately 2mm short of the binding point (Fig 7-13b). The heat is de-activated and pressure continued to advance the cooling tip to binding point (Fig 7-13c). Pressure is maintained for ten to fifteen seconds as the

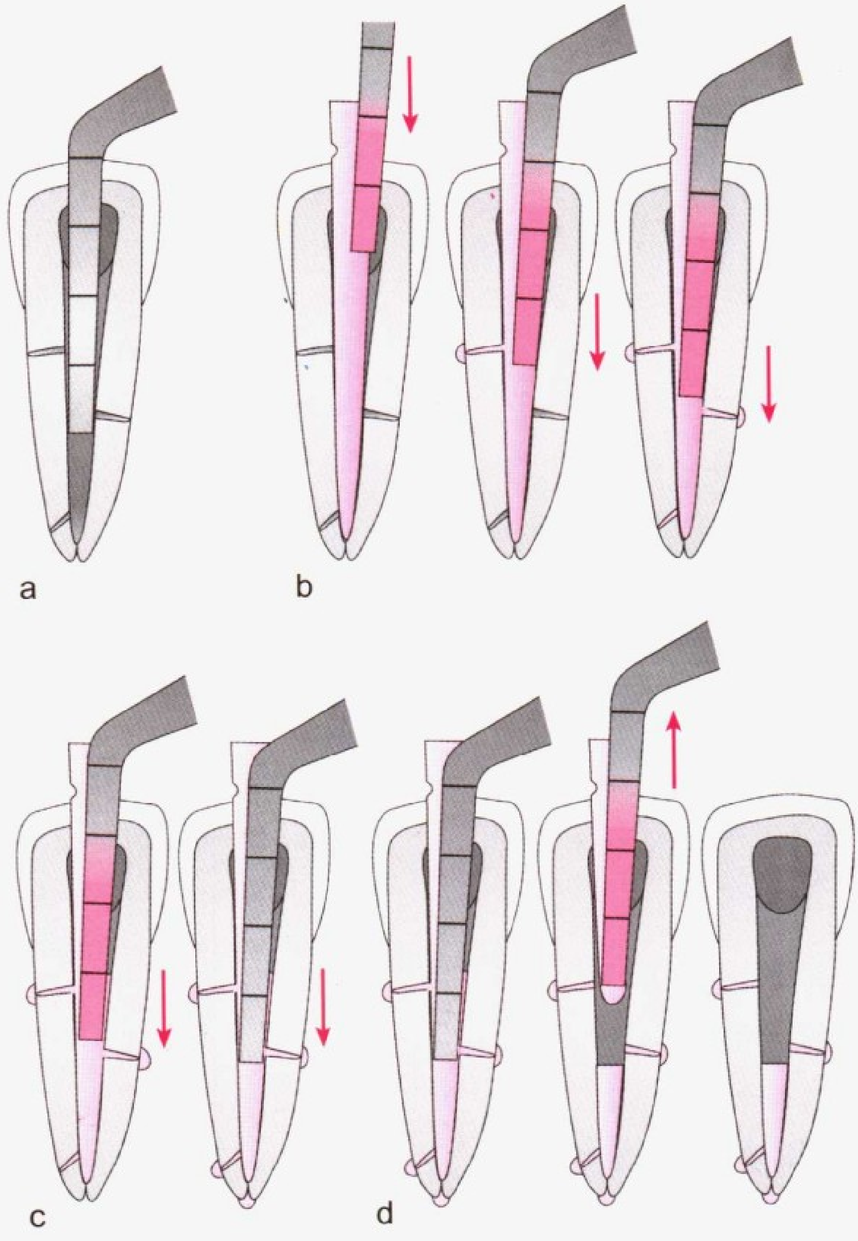


图 7-13 单波垂直充填。a. 选择一加热 / 充填枪头，要求进入根管后，其尖端距根尖 5 ~ 7mm，此处为结合点；b. 加热下压 2s，枪头尖端就到达距结合点 2mm 的位置；c. 停止激活后，冷却枪向下压至结合点处，持续 10 ~ 15s。在下压过程中充填材料的侧向运动会将二级解剖系统填满；d. 加热 1s 后瞬时分离移出枪头，根管内的多数内容物可一并取出，仅留下根尖 5 ~ 7mm 的充填材料

Fig 7-13 Single-wave vertical condensation. (a) Selecting a heater/plugger tip which binds 5–7mm short of working length. (b) Downpack takes two seconds as the warm tip descends to 2mm from binding point. (c) After deactivation, the cool tip is pressed to the binding point and held for ten to fifteen seconds. Secondary anatomy should have been filled by lateral movement of material during the downpack. (d) A one-second separation burst frees the tip and allows withdrawal. Most of the canal contents will also be removed, leaving 5–7 mm of material apically.

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•瞬间分离和后退，完成根管深部的充填。在加热／充填枪头接触的充填材料已经冷却后，再次加热1s，就可瞬间分离并取出加热／充填枪头（图7-13d）。此时结合点冠方的牙胶也被粘在枪头上，一并带出。

•采用不锈钢充填器或Buchanan镍钛充填器进一步压实根尖充填物。

•回填方法同前。若用System B®系统来加热回填的牙胶，其温度需降至约100℃。

无论是用单纯的单波加热，还是用来修整和加固其他牙胶的根管充填，System B®系统都是最灵活且易于使用的加热充填设备。它的热源由电池提供，温度可控，避免了其他加热方式如烧灼器械时温度的不连续性以及可能在口腔中产生的各种危险。

3．载体系统

Thermafil®（Maillefer/Dentsply）和Softcore®（Septodont）（图7-14）等载

apical plug of gutta percha cools and shrinks.

• Separation burst and withdrawal completes the downpack. Filling materials will have cooled in contact with the heater/plugger tip which can only be removed by activating the heat again for a one-second "separation burst" (Fig 7-13d). Gutta percha lying coronal to the binding point is removed, attached to the tip.

• Consolidation of the apical plug is achieved with the stainless steel or NiTi Buchanan plugger.

• Back-fill is then completed as before. If the System B® heat source is used for heating increments of back-fill gutta percha, its temperature can usefully be reduced to approximately 100℃.

The System B heat source is the most versatile and user-friendly device for warm compaction, either in a pure single wave technique, or to revise and consolidate any other gutta percha filling. Battery-operated heaters of this sort are predictable and do away with the dangers and inconsistencies of carrying red-hot instruments to the mouth.

3. Carrier systems

Carrier systems such as Thermafil® (Maillefer/Dentsply) and Softcore®

体系统使热塑充填的操作更为简便快捷。

- 根管应预备为平滑的 0.06 锥度的形态，并使用空白塑型载体或加压器进行验证，应能保证其顺利到达根尖止点（图 7-15a）。

(Septodont) (Fig 7-14) promise speed and simplicity in thermoplastic obturation.

- Preparation should be a smooth .06 taper and verified by trying in a blank plastic carrier/condenser, which should freely reach the canal terminus (Fig 7-15a).



图 7-14　牙胶尖载体系统

Fig 7-14　Gutta percha/carrier systems.

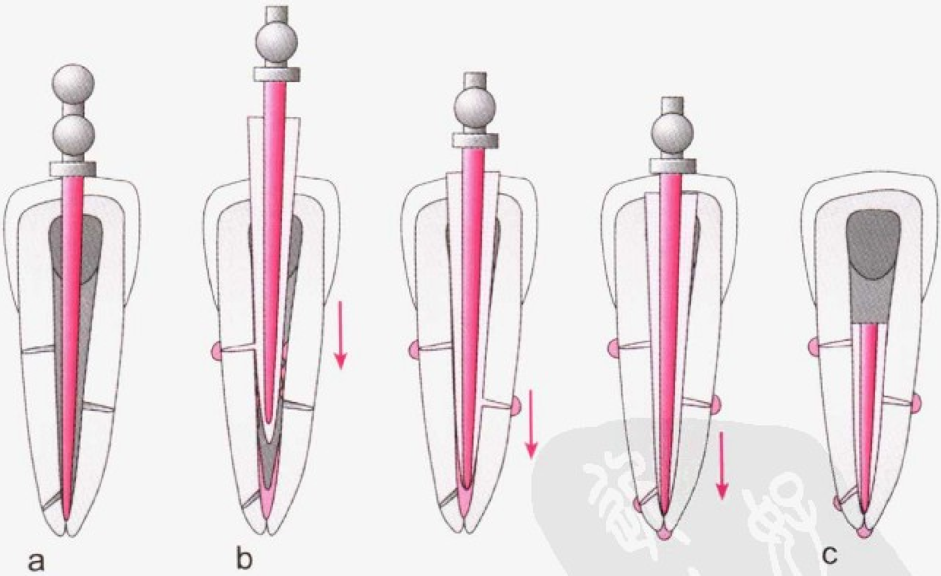


图 7-15　载体系统。a. 检验预备的根管；b. 将加热好的载体平滑、迅速地插入涂有一薄层封闭剂的根管中；c. 从深部切断手柄，以便有足够的空间进行冠方保护

Fig 7-15　Carrier systems. (a) Verification of the preparation. (b) Seating of the warmed carrier into a lightly sealer-coated canal, smoothly and without delay. (c) Severing the handle deep to allow adequate coronal protection.

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- 加热时务必完全、均匀，以保证牙胶的流动性，正确选择加热器和加热时间。
- 将牙胶尖载体平滑、迅速地插入预备完好且涂有一薄层封闭剂的根管中（图7-15b）。封闭剂涂布过量时可能会被挤出根尖孔，应予以避免。
- 为补偿冷却后的收缩，可在载体周围插入冷牙胶。
- 在冷却并加压1～2m后，用热器械或车针切断手柄（图7-15c）。需预备桩道间隙时，可使用专用的高速车针或慢速GG钻或Peezo钻。

与其他方法相比，如果处理得当，载体充填系统也能获得满意、快捷的效果，但此方法也有一些缺点：

- 无法就位。初始加热不完全或在插入过程中片刻的移位都可能影响牙胶尖平滑的插入和其流动性，从而影响充填效果。
- 牙胶尖从载体上脱离。如果根管预备不够平滑或与载体不匹配，在插入过程中牙胶尖可能脱落，只余留塑料空柄到达根尖，这将

- Heating must be complete and uniform for predictable flow, and the correct oven and heating time are essential.
- Carrier insertion should occur smoothly and rapidly in a well-prepared, lightly sealer-coated canal (Fig 7-15b). Excess sealer may shoot apically like the contents of a syringe and should be avoided.
- Cooling shrinkage should be countered by walking around the carrier with a cold plugger.
- After one to two minutes of cooling and compaction, the handle can be removed with a hot instrument or bur (Fig 7-15c). Post preparation is then possible, either with a dedicated high-speed bur or slow-speed Gates Glidden/Peezo drills.

Well done, carriers will deliver pleasing and rapid results, and it is likely that they will perform as well as any other method. However, there are some possible disadvantages:

- Failure to seat. Inadequate initial heating or a moment's distraction during insertion will compromise smooth insertion and flow, with disappointing consequences.
- Stripping of gutta percha from the carrier. If the preparation is not smooth or properly accommodating of the carrier, gutta percha may be wiped

严重影响根尖封闭的能力。

- 无法修正。如果充填不理想，由于塑料载体的存在，会妨碍修正和进一步的充填，而其他全牙胶尖充填方法均可进行修整直至满意为止。
- 难以取出。要取出部分就位的载体十分耗时。Thermafil® 装置上设置了一条凹槽以便于取出（图 7-16），但仍相当困难。
- 术后疼痛。载体系统可能会增加术后疼痛，但通常会在 24～48h 内消退。其原因可能是根管内容物由于压力过大被挤出根管所致。
- 对融合根管的充填较困难。过量的牙胶尖和封闭剂会被挤入第二根管，从而影响另一载体的就位。

该方法的优势在于充填较长的、重度弯曲的根管。若采用其他方法充填此类根管，则加热器和加压器均较困难，充填效果不理想（图 7-17）。

away during insertion, leaving a bare plastic core with severely compromised sealing ability at the apex.

- Inability to revise. In the event of disappointment, the presence of the plastic carrier thwarts any attempt to revise or advance the fill. This is in contrast with all-gutta-percha methods which can be revised until satisfied.
- Difficult removal. Retrieval of a part-seated carrier can be a time-consuming challenge. Thermafil® devices incorporate a groove for entry of instruments (Fig 7-16), but retrieval is still generally difficult.
- Postoperative pain. Carrier systems appear to be associated with increased postoperative pain, which usually resolves within 24 to 48 hours. Explanations may include extrusion of canal contents due to the great hydraulic pressures generated.
- Confluent canals present a special challenge. Excess gutta percha and sealer extrude into the second canal and may prevent full seating of the next carrier.

Positive indications include the very long or severely curved canal where the carriage of heat and compaction by any other method may be difficult (Fig 7-17).

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图7-16 V形凹槽便于取出Thermafi® 充填物

Fig 7-16 V-shaped notch to facilitate removal of Thermafil®.



图 7-17 在加热和加压器械无法足够深入时，采用载体系统充填，效果较为理想

Fig 7-17 A positive indication for carrier obturation, where heat and condensing instruments may be unable to penetrate deeply enough.

根尖孔敞开的患牙充填

牙根末端敞开的原因通常包括：

- 长期根尖周病变的患牙引起的牙根炎性吸收。
- 器械超出根尖。
- 儿童期创伤致使根尖尚未完全形成（图 7-18a）。

无论何种病因，这类问题都对如何完整地封闭根尖部提出了新的挑战。传统的方法包括：

- 反复使用氢氧化钙诱导根尖钙化屏障的形成。
- 利用氢氧化钙粉形成根尖屏障，以阻止牙胶尖超出。
- 加热或溶解后，制作大号牙胶尖

The Challenge of the Open Apex

Open root-ends commonly result from:

- apical inflammatory root resorption in teeth with long-standing apical periodontitis
- over-instrumentation beyond the root terminus
- failure of root formation after childhood trauma (Fig 7-18a).

Regardless of the aetiology, open root ends present a challenge for controlled and well-sealing obturation. Traditional approaches have included:

- repeated calcium hydroxide dressings to grow a calcific apical barrier
- generation of an apical barrier with calcium hydroxide powder to pack gutta percha against
- customising large gutta percha cones

进行充填。

• 根尖外科手术。

在各种修复（包括穿孔修复）中，应用矿化三氧化物聚合体（Mineral Trioxide Aggregate，MTA）进行非手术治疗开始日益增多。这种材料特点为：

• 在波特兰建筑用水门汀的基础上研制而成。

• 用水调拌后，质地坚韧。

• 用长的充填器和纸尖逐次将MTA送至穿孔处，进行充填和振荡，可获得无可比拟的根尖封闭性及根尖周生物学再生效果（图7-18b）。

将湿棉花轻轻覆盖在充填物上，以保持湿润，然后进行冠方严密封闭，

with heat or solvents

• root-end surgery.

Increasingly, this and other types of repair (including perforation repairs) are achieved non-surgically with Mineral Trioxide Aggregate (MTA), an exciting material:

• based on Portland building cement

• mixed to a stiff, gritty consistency with water

• packed and vibrated in increments with long pluggers and paper points to deliver unsurpassed sealing and bioregenerative results in the apical periodontium (Fig 7-18b).

The filling should be kept moist by gentle overlaying with moistened cotton wool and

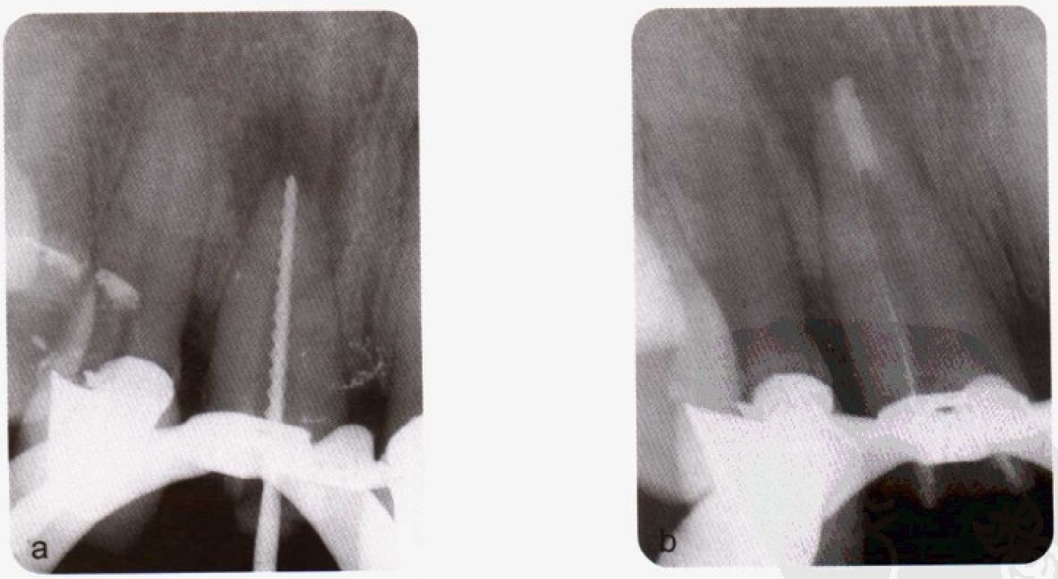


图 7-18　a. 对损伤后开放的根尖进行充填是目前面临的困难之一；b. 完整的 MTA 充填

Fig 7-18 (a) The damaged, open apex presents special challenges for controlled obturation. (b) completed MTA compaction.

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充填物可在数小时内固化。充填24h后及牙齿最终修复前，应对材料进行检查确保其已经完全固化。

a tight coronal seal, and will set within a few hours. Setting should be confirmed by inspecting and probing the material at least 24 hours after placement and before definitive resoration of the tooth.

MTA是手术及非手术牙髓治疗中的一种特殊材料，其有可能衍生出新的用法和配方。然而目前的MTA，一方面操作性能较差（易碎且具有类似浮石和水的特性），另一方面，在美观要求较高的区域有色素沉积的倾向，因此其应用受到一定的限制。如果改进了这些缺陷，MTA可能会替代牙胶尖和封闭剂，成为一种最常用的根管充填材料。

MTA is emerging as an exceptional material in non-surgical and surgical endodontics, and is likely to develop many new roles and formulations. However, applications are currently limited by poor handling characteristics (crumbly, and with behaviour like pumice and water), and the propensity to tattoo tissues in aesthetically sensitive areas. Until these properties are improved, it is unlikely to displace gutta percha and sealer as the material of choice for most filling applications.

术后注意事项

虽然术后急性严重反应的发生率较低，但应告知患者，术后48h可能会出现轻微不适，需口服止痛药。还应告知患者对根管治疗后的患牙进行及时正确修复的重要性。

Postoperative Warnings

Although the likelihood of serious postoperative flare-up is low, all endodontic patients should be dismissed with the warning that they may experience minor discomfort and require simple analgesia for the next 48 hours. They should also be notified of the importance of getting a root-canal-treated tooth properly restored.

牙根充填物的保护

大多数人都将注意力集中在根管的预备和充填上，但还应引起注意的是根管充填后的微渗漏，根管充填后应与口腔菌群隔绝。有研究显示，在

Protection of Root Fillings

For all of our focus on preparation and obturation, it should be remembered that gutta percha/sealer root fillings leak and should be protected from the oral flora.

4～40d 内，涎液可渗透至充填完好的整段根管内。即使根管充填良好也不应忽视这种原因引起的失败。所以，应从较深的部位切断牙胶尖和封闭剂，为良好的封闭性修复材料提供至少3mm的厚度，以便与根管壁紧密贴合。术后还应对牙尖进行保护以防止折裂。

Some studies have shown that the human salivary flora penetrates the full length of a well-compacted root filling within four to 40 days. The spectre of failure should not be underestimated in the excitement of a pleasing root filling. Gutta percha and sealer should be cut back deeply to provide at least 3mm thickness of well-sealing restorative material, adapted with care against the walls of the preparation. Cuspal protection should also be provided for teeth vulnerable to fracture.

结 论

- 预备后的根管如果不进行充填和冠方封闭，则无法长期保持健康的环境。
- 采用各种冷、热牙胶充填技术对预备良好的根管进行牙胶尖和封闭剂充填，可获得满意的充填效果。
- 对根管进行三维充填的方法今后可能会更有优势，尽管目前还没有对此进行证实。
- 牙胶尖和封闭剂仍是根管充填的金标准，其他材料如MTA的应用越来越广泛。

Conclusions

- The healthy environment of a prepared root canal will not be sustained long-term without obturation and coronal seal.
- Satisfactory root canal fillings can be achieved in well-prepared canals with gutta percha and sealer compacted by a varicty of cold and warm techniques.
- Although there is little evidence currently of improved outcomes, it is rational to assume that techniques better able to obliterate three-dimensionally the pulp canal space are preferable.
- Whilst gutta percha and sealer remains the gold standard, alternatives including MTA are justifiably gaining acceptance in a variety of settings.

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拓展阅读

Further Reading

1 Gutmann JL, Witherspoon DE. Obturation of the cleaned and shaped root canal system. In: Cohen S, Burns RC (Eds.) Pathways of the Pulp. 8th ed. St Louis: Mosby, 2002: 293–364

2 Root canal obturation. In: Beer R, Baumann MA, Kim S (Eds.) Color Atlas of Dental Medicine. Endodontology. Stuttgart: Thieme, 2000:165–198

第 8 章 治疗的成功与失败

Success and Failure

目　的

本章阐述了牙髓治疗成功的最低要求及更为严格的定义，并回顾了影响疗效的因素，提出了治疗完成后定期对其进行评估的基本原则。

Aim

To outline minimalist and more stringent definitions of endodontic success, review factors affecting outcome and develop a rational basis for evaluating treatment at intervals after its completion.

要　点

通过学习本章，对影响根管治疗成功的相关因素有更为清晰的认识；进一步了解治疗后不同时段的进展；以及不能有效控制感染的后果。

Outcome

After studying this chapter, the reader should have a clearer understanding of factors associated with successful root canal treatment; the signs of progress at intervals after treatment; and the consequences of inadequate infection control.

结果的判定

人们对问题的认识取决于其看问题的角度。患者、医师、专家及保健机构对于包括根管治疗在内的治疗上的成功都十分关注。虽然临床专家常常提出成功与失败的＂官方＂标准，但每个人还都有自己可以接受的标准。这个标准可以是＂到目前为止患者无不适主诉＂这样的最低要求，也可以是

Defining Outcome

Where you stand on an issue depends on where you sit. Patients, clinicians, academics and healthcare organisations all have an interest in successful therapies, including root canal treatment. Whilst clinical academics usually develop "official" definitions of success and failure, everyone has a working understanding of what they con-

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˝组织学上炎症消退，恢复至初始的健康状态˝这样很严格的标准。这两个极端都不合理。

sider acceptable. This can range from a minimalist "uncomplaining patient with tooth still present" to a stringent "histological resolution of inflammation and return of tissues to pristine health". Both extremes may be unreasonable.

成功的最低标准

根管治疗包括对有疼痛症状的牙齿进行治疗，也包括对很多无症状牙齿进行治疗，在后者的治疗中，患者并不了解其牙髓已经坏死或已产生了根尖周炎。如果治疗的目的是阻止并治愈疾病，那么就不应仅仅维持疾病的现有状态。根管治疗后出现根尖周病变或原有病变并未缩小或没有愈合，就说明尚未彻底控制感染源，治疗并未达到其治疗目的（图8-1）。

Minimalist Definitions of Success

Root canal treatments are often provided for teeth with painful symptoms, but equal numbers are provided for uncomplaining patients, unaware of their necrotic pulp and apical periodontitis. If treatment is offered to prevent and cure disease, it must do more than simply preserve a diseased status quo. Emergence of apical periodontitis, or failure of it to diminish or heal after root canal treatment can only mean that the aetiological agents were inadequately managed and that treatment did not meet its objectives (Fig 8-1).



图8-1 无症状的病例并不代表真正的成功

Fig 8-1 A symptom-free case, but can this really represent success?

成功的严格标准

达到组织学上的完全成功并不现实。即使可以进行组织学检测，活检的结果也通常令人失望，因为治疗后根尖周组织不含炎症细胞的牙齿几乎不存在。

Stringent Definitions of Success

Histological monitoring of success is equally unrealistic. Even if they were justified, biopsy results would be disappointing, with few treated teeth completely free of periapical inflammatory cells.

官方标准

此标准力求达到合二为一的合理标准，其中既包括患者的舒适度和牙齿功能的行使，还包括其他一些愈合指征，如：

- 无疼痛、肿胀及其他牙髓源性症状。
- 无黏膜或牙周膜的牙髓源性窦道。
- 咀嚼功能不受限。
- X 线片显示根尖牙周膜间隙正常。

标准指出，无症状的根尖周病变如果保持原样或仅有面积上的缩小，则不能算作成功。即使不做进一步的治疗，也应对这种病例定期回访。

Official Definitions

These try to strike a rational middle ground, embracing patient comfort and function as well as reasonable evidence of healing:

- No pain, swelling or other symptoms of endodontic origin.
- No sinus tract of endodontic origin, either through the mucosa or through the periodontal ligament.
- No limitation of chewing function.
- Radiographic evidence of a normal periodontal ligament space around the root.

Guidelines consistently note that a symptom-free periapical lesion which remains unchanged or only diminishes in size can not be counted as success and most commonly demands further review if not further treatment.

成功和失败的影响因素

根管治疗成功与否与以下因素有

Factors Associated with Success and Failure

Achieving a successful outcome in the

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关：

- 患者及患牙的术前状况。
- 医师所提供的治疗方法。
- 治疗后患牙的维护。

terms defined can be influenced by the:

- preoperative condition of the patient and tooth
- treatment provided
- management and maintenance of the tooth after treatment.

患者及患牙的术前状况

Preoperative Condition of the Patient and Tooth

患者的年龄、性别和健康状况

由于根尖周炎症代表着根管内感染与宿主防御能力之间的平衡状况，因此可以认为，宿主因素会对治疗效果产生重要影响，但目前还没有证据可证明上述推断，因此根管治疗几乎没有禁忌证。但严重免疫功能低下和需要进行颌骨放射治疗的患者，愈合速度可能比其他患者慢，愈后也较差，最好将患牙拔除。

Age, gender and health of the patient

Since apical periodontitis represents a balance between intracanal infection and host defences, it might be assumed that host factors would exert a major influence on treatment outcome. Surprisingly, there is little indication that they do, and there are consequently few contraindications for root canal treatment. However, severely immunocompromised and patients about to undergo radiotherapy to the jaws may not heal as quickly and predictably as others, and extraction with medical liaison is usually the preferred treatment for apical periodontitis in such cases.

根尖周炎症的出现

这是影响牙髓治疗疗效的最重要一个因素。

- 治疗前没有根尖周炎的牙齿比患有根尖周炎的牙齿更易于保持根尖健康，更易于彻底愈合。

Presence of apical periodontitis

This is the single most important factor in studies of endodontic outcome.

- Teeth without apical periodontitis are more likely to maintain apical health after treatment than teeth with apical periodontitis are likely completely to

- 由于根尖周状态对于判断成功与否十分重要，因此与有牙髓坏死及根尖周炎相比，没有根尖周炎的患牙（不可逆性牙髓病变）成功率要高出约 25%（图 8-2a，b）。

目前还无法证实，有根尖周炎和无根尖周炎的牙齿，根管治疗在缓解不适、恢复功能方面哪一种效果更好。

根尖病变的大小

根尖病变的发展由多年持续发展而来。直径>5mm的病变与直径<5mm的病变相比，其骨组织修复的速度较慢。当然也有例外（图 1-8），大的病变可通过软组织形成瘢痕来愈合，但这种愈合与持续性炎症很难区别。

heal.

- Since apical status is important in defining success, teeth without apical periodontitis (irreversible pulpitis cases) are approximately 25% more likely to be successful than cases with pulp necrosis and established apical periodontitis (Fig 8-2 a,b).

There are few studies to show that root canal treatment restores comfort and function more predictably for teeth with or without apical periodontitis.

Size of periapical lesion

Periapical lesions can develop over many years. Lesions > 5mm diameter may be expected to fill with bone more slowly than those < 5mm diameter. There are, of course, exceptions (Fig 1-8), and large lesions can heal by soft-tissue scarring which may be

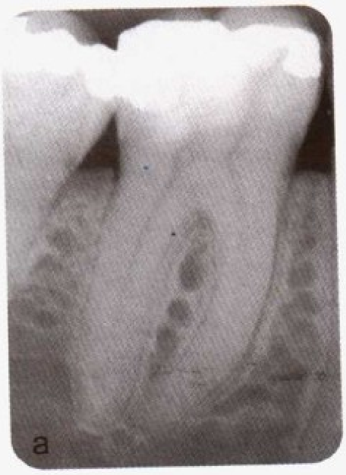




图 8-2 从根尖周组织的健康角度来说，图（a）中的患牙在根管治疗后比图（b）中的患牙更容易成功

Fig 8-2 (a) Root canal treatment of this tooth is more likely to be successful in terms of periapical health at review than (b).

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difficult to distinguish from persistent inflammation.

牙齿的位置和状况

牙髓切除术和根管治疗术可消除牙髓炎症状，并治愈根尖周病变。目前还无法证明，使用同样的治疗方法，磨牙的疗效是否比其他牙齿更差，但以下因素可能会影响疗效：

- 冠部破损。
- 解剖结构复杂。
- 根管难以进入。
- 根管钙化。
- 根管弯曲。
- 隐裂。

这些因素多见于多根后牙中，因此疗效难以确定。

Condition and position of the tooth

Pulpectomy and root canal treatment predictably relieve symptoms of pulpitis and heal apical periodontitis. There is no convincing evidence that molars and their surrounding tissues are less responsive to treatment than any other tooth. However, factors which may compromise treatment such as:

- coronal breakdown
- anatomical complexity
- difficult access
- calcification
- curvature
- cracks

may be more prevalent or multiply represented in multi-rooted posterior teeth, making their treatment appear less predictable.

根管内菌群或根尖周病变的性质

大多数病变来源于感染，经过根管预备可以去除这种感染，但也有例外：

- 根管内感染物质对常规治疗方法产生抵抗。
- 常规方法无法到达的根外感染区域。

Nature of the canal flora or periapical lesion

Most apical lesions are sustained by infections which are disrupted or eliminated by canal preparation. However, there are instances of:

- intracanal infection resistant to normal measures
- extraradicular infections inaccessible to routine procedures

- 与根管内感染无关的根尖周病变（参见第 1 章）。

这些病例在所有根尖周炎病例中的比例不超过5%，目前还无法对其进行诊断。根管的气味和病变边缘的表现（皮质化或非皮质化）并不是愈后的指标。

- periapical lesions independent of intracanal infection (see Chapter 1).

These probably represent less than 5% of all cases with apical periodontitis and diagnostics are currently unable to detect them. The smell of a root canal and the appearancc of a lesion's margins (corticated or not) are not prognostic indicators.

所提供的治疗

本书主要是介绍根管的进入、预备和充填。研究下面的这些问题会为促进愈合提供理论指导：

- 适中的根尖区扩大还是增大根尖区的扩大。
- 适中的根管锥度还是增大根管锥度。
- 选用较强的还是较弱的冲洗液。
- 冷侧压充填还是加热垂直充填。
- 是否希望通过充填材料阐明复杂的解剖结构。
- 根管封闭剂的选择。
- 根管治疗的一次法与多次法。

遗憾的是，含有长期回访资料的临床随机对照试验还很少，只有随访时间足够长，得出的结论才有指导意义。

The Treatment Provided

Much of this book has been devoted to technical aspects of root canal access, preparation and obturation. It would be reasonable to assume that studies were available to give strong guidance on which techniques promote better healing:

- modest v. increased apical enlargement
- modest v. increased canal taper
- irrigation with weak or strong bleach
- cold lateral condensation v. warm vertical condensation
- demonstration of complex anatomy with filling materials
- choice of root canal sealer
- single- v. multiple-visit treatment.

Regrettably, few procedures have been subjected to randomised clinical trials with follow-up of sufficient duration, and guidelines are only available in the broadest terms.

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根管充填的质量

根管治疗的成功与术后X线片中的根管充填影像密切相关：

- 充填物局限于牙齿内。
- 充填物距离根尖<2mm。
- 充填材料与根尖、根管侧壁之间，以及充填物内部无空隙（图8-3）。

能努力达到上述标准的医师，在控制感染的其他方面一般也会做得很好。

持续的根管感染

若充填时根管内的细菌培养呈阳性，则根尖周病变愈合的概率会从95%降至70%。一些影响进入根管系统的操作失误，也会影响整个根管的消毒，例如：

Quality of the Root Filling

Success is most strongly associated with cases in which the postoperative radiograph shows a root filling:

- contained within the tooth
- extending to within 2mm of the root-end
- with no evidence of empty space apical to, lateral to, or within the body of filling material (Fig 8-3).

It may be realistic to assume that practitioners who strive to achieve these outcomes also embrace other aspects of treatment to control infection.

Persistent Root Canal Infection

The presence of cultivable bacteria in root canals at the time of filling reduces the likelihood of periapical healing from almost 95% to less than 70%. Procedural accidents which deny access to the whole canal for disinfection, such as:



图8-3 显示了一有望获得成功的根管治疗病例，充填物达到根尖2mm内，且无空隙。只有所有的操作步骤都很完善，才能获得成功。若根管充填物被涎液污染，则其效果还不如那些表面看起来不十分美观但根管未被污染的根充效果好

Fig 8-3 A root canal treatment expected to succeed, filled to within 2mm of root-end and with no real evidence of porosity. But this assumes all was done well. If the filling incorporated saliva, it may perform less well than a less aesthetically pleasing one packed in a clean canal.

- 台阶形成。
- 感染碎屑阻塞根管。
- 器械折断。

这些都会对治疗的成功产生较大影响。

同样，根管封闭的操作失误包括：

- 根尖偏移。
- 器械超出导致根尖孔被破坏。
- 根管侧穿。
- 牙根折裂。

这些都会对保持清洁的根管内环境及预防新病变的产生造成不利影响。

从理论上说，可将以上危险因素降至最低的任何方法都会改善治疗的效果。

- ledging
- blocking canals with infected debris
- fracturing instruments

are therefore likely to impact heavily on success.

Similarly, accidents which compromise the development of a seal including:

- apical transportation
- destruction of the root terminus by over-instrumentation
- lateral root perforation
- splitting of the root

will foil attempts to preserve a clean environment and prevent new lesions from developing.

Logically, contemporary methods which minimise some of these risks should improve outcomes.

治疗后患牙的处理和维护

术后修复

根管充填后如不能及时对牙齿和根充物进行保护，再好的根管充填治疗也无法保证患牙无痛、长期行使功能及根尖周组织的愈合。

根管治疗失败的原因包括：

- 折裂。
- 根管再次感染或口腔内的营养物质渗入。

良好的冠修复会保护患牙，防止意外发生。

Management and Maintenance of the Tooth after Treatment

Postoperative restoration

A well carried out root filling is no guarantee of painless, life-long function and periapical healing if the tooth and root filling are not immediately protected.

Root canal treated teeth can fail because of:

- fracture
- reinfection or entry of nutrient fluids from the mouth.

An adequate coronal restoration protects against both eventualities.

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• 对于后牙，可行根尖牙尖保护或者复合树脂修复这样简单的处理。可将材料延伸至根管内，然后用粘结系统进行粘结（图 8-4）。

• 临时桩冠易产生冠部的微渗漏（图 8-5）。最好的方法是在铸造桩粘固前，先将前牙冠方进行简单的封闭，或在根管治疗后，直接用成品桩进行桩核修复。冠应对牙体组织进行完全包绕以防止折裂。

• For posterior teeth, that can be as simple as a cuspal coverage amalgam or composite restoration, extended well into the root canals, and bonded with a contemporary adhesive system (Fig 8-4).

• Temporary post crowns are especially vulnerable to coronal microleakage (Fig 8-5). Ideally, an anterior tooth should be sealed with a simple coronal plug until a cast post is ready for cementation, or a direct post/core provided immediately after root canal



图8-4 显示了一个制作良好的临时塑料修复体，修复体延伸至根管内以获得冠方封闭并提供牙尖保护

Fig 8-4 A well-conducted interim plastic restoration extended well into the canals for coronal seal and affording cuspal protection. (Courtesy G V Seccombe).



图 8-5 前牙的临时桩冠 – 冠部易微渗漏。在铸造桩粘固前，最好先用水门汀暂封，或在根管治疗后立即用成品桩核进行修复

Fig 8-5 Temporary anterior post crowns – especially vulnerable to coronal microleakage. Ideally, the root would be sealed with a simple cement plug until a cast post was ready, or a direct post/core provided immediately the root canal treatment is complete.

treatment. Crowns should provide wrap-around protection of tooth tissue to guard against fracture.

- 桩道预备时常会导致根管壁薄弱及穿孔，这是引起失败的最主要的原因（图8-6）。目前，越来越多的人认为只有在确实需要时，才可使用桩冠。

- Post space preparation is frequently associated with root weakening and perforation; two prominent causes of failure (Fig 8-6). Consensus is growing that posts should be used only when necessary to support and retain coronal restorations.

- 起保护和密闭作用的塑料修复体可持续使用数年，但如果其他的非牙髓病有可能导致患牙缺失时，应及时进行永久性保护和封闭性的修复。

- Protective and well-sealing plastic restorations can serve adequatly for many years, but definitive protecting and sealing restorations should not be unduly delayed if the tooth remains vulnerable to loss for non endodontic reasons.

进行维护

无髓牙和其他牙齿一样易于发生龋坏。由于再次发生龋坏不会出现牙齿敏感症状，这时若没有及时检查，病

Ongoing maintenance

Pulpless teeth are as vulnerable to caries as any other. They are unlikely to become sensitive if recurrent caries develops, and



图8-6 桩道预备时的操作失误是引起失败的主要原因。因此如无必要，尽量不要使用桩修复

Fig 8-6 Catastrophic post space preparation—a common cause of failure and good reason to avoid posts unless needed.

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变会隐匿地破坏牙冠，再次感染根管系统（图8-7）。牙齿的X线片可能无法检测早期的冠部龋坏及修复物边缘的破坏。

lesions can quietly destroy the crown and reinfect the canal system if there is inadequate surveillance (Fig 8-7). Bisecting angle radiographs may not detect early coronal caries or marginal restoration breakdown.

治疗后定期从各个方面评估成功与失败

Assessing Success and Failure from Different Perspectives at Intervals after Treatment

根管即刻封闭之后

Immediately after closure of the tooth

刚完成治疗的牙齿，无法从患者的表现来判定成功与否。轻微不适并不能代表最终的愈后结果。应告知患者，术后几天可能出现轻微症状，这时需服用止痛药。

Immediately after treatment, patients have few terms of reference to define success. Mild discomfort is usually no indicator of eventual outcome, and all patients should be advised to expect minor symptoms which may require simple analgesics for a few days.

医师应清楚参考指标，并根据以下知识来判断疗效、疼痛缓解的可能性，以及根尖周组织的愈合情况：

Terms of reference are clearer for the clinician, who will judge his outcome and likelihood of pain relief and periapical healing on the basis of his knowledge of:

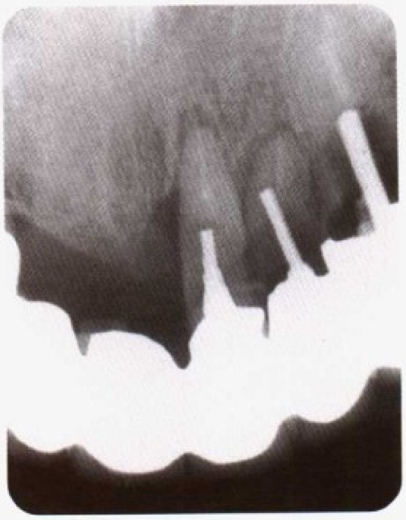


图8-7 隐匿性的破坏。牙齿再次发生龋坏时没有症状。大面积的龋坏破坏冠部，并再次感染治疗后的根管系统

Fig 8-7 Silent destruction. Extensive caries has painlessly destroyed the crowns and reinfected the canal systems of these root canal treated teeth.

- 所做的治疗。
- 操作过程中有无严重错误或失误。
- 根管充填后的 X 线片。

依靠健康保健系统，付费机构可以根据术后 X 线显示的根管内的白色阻射线，对效果作出自己的判断（图8-8），无需再看是否成功愈合。

- what he did
- any serious procedural errors or compromises
- the radiographic appearance of the root filling.

Depending on the healthcare system, fee-paying authorities may make their judgement on the outcome based purely on the immediate postoperative radiographic appearance of the radiopaque white lines in the root canals (Fig 8-8). None demands to see evidence of successful healing.

治疗后一周内

有效的治疗应具有以下特征：

- 疼痛和肿胀消退或显著减轻。
- 窦道闭合。
- 咀嚼功能恢复。

此时治疗费用应缴齐，患者比较满意，没有怨言。一些轻微的症状偶尔也会持续一周以上，但在一个月内应完全

Within one week of treatment

Effective treatment should have:

- eliminated or substantially reduced pain and swelling
- closed sinus tracts
- restored chewing function.

The patient's fee should have been paid, indicating satisfaction and no serious complaints. Occasionally, minor clinical



图 8-8　对付费机构而言，属于不成功的病例，不值得付费，也未达到预期的目标

Fig 8-8　Success for the paymaster? Does this treatment justify the fee? Is it likely to achieve its desired goals?

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消退。

在此阶段，患者会认为治疗已完全成功，并希望患牙以后都不会出现症状且可以正常使用。根据这些情况，临床医师也会认为治疗已经成功，无需再定期检查根尖周组织的严格愈合指标以及定期维护。

symptoms persist after one week, but should be fully resolved within one month.

At this point, the patient may regard the treatment as a complete success with an expectation of symptom-free function for life. Depending on practice circumstances, clinicians may argue strongly that a successful outcome has been achieved, and make no further review of the case to check on the more stringent parameter of periapical healing or maintenance of health.

治疗后六个月内

由下述标准可推断已获得成功：

- 无复诊出现。
- 申请回访时无症状或炎症症状消退。

建议，如果有下列症状，应再次拍摄X线片，检查根尖愈合情况：

- 出现临床征象或症状。
- 重新进行永久性修复。

术后一年拍摄X线片才具有实际意义。术后六个月的X线片可能会显示病变有所改善，但治疗期间碎屑被推出根尖孔所引起的暂时性病变，需一年时间才会完全消失。

Within six months of treatment

Success may be inferred by:

- no unscheduled patient attendances
- the absence of symptoms or symptom-free signs of inflammation at recall.

When Should Periapical Healing be Reviewed Radiographically? Guidelines suggest that unless there are:

- signs or symptoms of concern
- foundations are being checked for definitive reconstruction

there is no value in radiographic review until one year post-operatively Films at six months may give some indication of improvement, but transient lesions can develop in response to debris pushed apically during treatment, which will resolve by one year.

术后一年

术后一年出现临床征象或症状均

One year after treatment

Clinical signs and symptoms which have

说明治疗失败，需与患者共同评估和讨论，然后进行下一步的治疗。

emerged one year after treatment indicate that the case is failing, and that further care is needed after evaluation and discussion with the patient.

此时：

- 约 90%正处于愈合期的根尖周病变会显示出有明显的改善，50%会完全愈合。
- 如果没有其他新的原因，如继发龋或桩冠松动等，那些体积已减小的病变会继续愈合。
- 无变化的病变并不一定代表失败，但存在问题。应随访 12 个月。虽然此类病例并未出现新的症状或体征，但仍应随访 4 年，每年拍 1 次 X 线片。若 4 年后仍未愈合，就可最后判断治疗是否成功。

By this time:

- Approximately 90% of the periapical lesions which are going to heal will show clear signs of improvement, and 50% will have completely healed.
- Lesions which have diminished in size may be expected to continue healing unless new factors such as recurrent caries or loosening of a post-crown intervene.
- Lesions which appear to be unchanged are not necessarily failing, but are questionable and should be reviewed in a further twelve months. In the absence of new signs or symptoms, persistent lesions of this sort should be monitored for up to four years with annual radiographs. No further healing is likely after four years, and a final judgement can be made on whether the treatment succeeded or failed to prevent or heal apical periodontitis.

为什么失败也很重要？

症状持续或继续发展（疼痛、窦道内有渗出、咀嚼功能降低）

患者会很清楚地意识到自己的症状并未缓解或消失，因此会寻求补救

Why is Failure Important?

Persistence or development of symptoms (pain, discharging sinus, compromised chewing ability)

Failure to prevent or resolve symptoms is clearly recognised by patients who may

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或索赔。如果在治疗后症状并未消失或立即出现了新的症状，应及时处理；若待症状持续了几年再进行处理，情况会更复杂。

在治疗一开始就告诉患者有90%的成功率很不明智，因为在术中或术后任何感染控制上的欠缺都会严重影响预后。然而，如果在根管进入、预备、充填和保护过程中都没有严重失误，就不会持续出现牙髓和根尖周症状。

seek remedy or recompense. Their case is less clear if symptoms develop several years after treatment rather than presenting symptoms failing to resolve or new symptoms emerging soon after treatment.

It is foolish to offer 90% success rates to patients at the outset of treatment, since any compromise of infection control during or after treatment can impact seriously on prognosis. However, persistent pulpal and periapical symptoms are unlikely provided that all root canals are entered, prepared, filled and protected without serious procedural error.

持续的根尖周射影

• 急性发作的危险。持续的慢性病变随时有可能急性发作（图8-9）。虽然这种可能性并未进行仔细量化，但每年约有 5%慢性根尖周炎的患牙可能会急性发作（即10年内约50%）。大多数牙医都认为急性发作难以预料，而且发病时间不确定。对宿主菌群之间平衡的破坏（如更换修复体），更易导致急性发作。

Persistence of a periapical radiolucency

• The risk of acute flare-up. It is always a concern that persistent chronic lesions are flare-ups waiting to happen (Fig 8-9). The threat has never been properly quantified, but may involve 5% of teeth with chronic apical periodontitis in any year (i.e. 50% in a ten-year period). However, it is the experience of most dentists that these lesions are unpredictable, and most have witnessed the painful consequences at the most inopportune times. Interventions which upset the host-microbe equilibrium, such as replacing a restoration, are particularly likely to precipitate events.



图8-9 持续的慢性根尖周炎有可能急性发作，在这种情况下进行牙齿修复没有把握

Fig 8-9 Persistent chronic apical periodontitis: what is the real risk of acute flare-up? Does any planned restorative work undermine confidence in this tooth remaining quiet?

- 慢性感染的潜在威胁。目前已证实慢性边缘性龈炎与系统性疾病之间存在联系。根尖周炎症同样也是由类似细菌介导的慢性炎性，可能会产生类似的危险。患者可能希望看到的是，所治疗的不仅是牙齿疾病，而且通过治疗还可以消除罹患其他疾病的危险。

我们都应注意检查治疗的结果。临床及放射线检查的回访是检查的核心。应将失败转化为经验，更好地控制感染和治愈疾病。

- The potential threat of chronic infection. Links are becoming established between chronic marginal periodontitis and systemic disorders. Apical periodontitis is a similar, microbially mediated chronic inflammatory disease, and may pose similar threats. Patients may increasingly wish to see evidence that the treatment they receive cures them of the disease and eliminates other health risks, rather than simply suppressing overt symptoms.

We should all have an interest to audit the outcome of the care we prescribe and deliver. Clinical and radiographic follow-up is central to that process, and the failures we all encounter should translate into a review of our practices to control infection better and heal more lesions.

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结 论

- 根管治疗对于预防和治愈根尖周炎症十分有效，成功率高达90%。
- 术前状态、医师所提供的治疗以及术后对牙齿的处理都会对愈后产生深远影响。
- 在根尖周炎的治疗中，尚无直接证据显示有哪一种技术效果最好。
- 患者、牙医以及健康保健机构应尽力确保疾病的治愈，而不应仅局限于获得令人满意的X线片或维持现状。

Conclusions

- Root canal treatment is effective in preventing and healing apical periodontitis, with success often quoted as 90%.
- The preoperative state, the treatment provided, and the management of the tooth after treatment, can seriously influence prognosis.
- There is little direct evidence to show which specific techniques treat apical periodontitis best.
- Patients, dentists and healthcare organisations should have an interest in ensuring that treatments heal disease, not simply produce pleasing radiographs or preserve a diseased status quo.

拓展阅读
Further Reading

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